

BUILDING REPAIRS
AND MAINTENANCE

BUILDING REPAIRS AND MAINTENANCE

DEALING WITH THE SURVEY OF PREMISES,
DEMOLITIONS AND REPAIRS TO STRUCTURE
AND SUPPLY SERVICES OF BUILDINGS

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WITH 103 ILLUSTRATIONS

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PREFACE

THE repair of buildings is not merely a matter of having each item attended to by the appropriate tradesman. It is a trade in itself, calling for special experience and theoretical knowledge. One item may involve several trades at once, and the methods employed may be quite different from those used in new work. The material, too, may be different. For example, a mortar suitable for pointing new brickwork may have a disastrous effect on old brickwork.

Until recently it was thought that repairs were jobs for the handyman type of tradesman who could tackle several trades with a fair degree of success. Modern research has shown that a sound knowledge of materials, the effects of weather, atmospheric pollution, the causes of decay and corrosion and the altered nature of old materials are necessary if repair methods are to be successful.

In the repair of ancient buildings for instance, special problems are encountered. Care and judgment are necessary to avoid repairs or restorations which might spoil the appearance of the building. It is also necessary to avoid treatment which might result in further decay of the old materials, and to remember that the main aim is to leave the old work as little altered in appearance as possible.

Chapter I deals with the correct methods of surveying premises, both for the production of plans and for dilapidations and defects, while Chapter II outlines the order in which it is advisable to carry out Inspection and Measurement when Estimating.

Sites, subsoils and foundations and the related subjects of demolition and shoring are dealt with in Chapters III and IV.

The construction, repair and renovation of walls forms the subject of the next four chapters, and it will be seen that the important aspect of damp proofing and the prevention of condensation have been given a separate chapter.

Equally detailed treatment has been given to every section of house repair and maintenance, including such items as smoky chimneys and their cure, dry rot and its prevention, sound and thermal insulation, as well as the more obvious aspects such as the repair of joinery work, roofing repairs, window glazing, painting and decorating.

"BUILDING REPAIRS AND MAINTENANCE" has in fact been designed to enable builders and building operatives to deal confidently with

any type of building repair, and to see that the work is carried out in a satisfactory and expeditious manner.

For detailed studies of scientific problems and materials the repairer is strongly advised to consult the bulletins and special reports of the Building Research Board of the Department of Scientific and Industrial Research, published by H.M. Stationery Office. The Building Research Station, Garston, near Watford, Herts, in addition to the valuable research work on which the Board's publications are based, advises on specific problems. But it is advisable first to consult a list of the reports and bulletins to see if the problem is already covered.

EDGAR LUCAS.

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BUILDING REPAIRS

Chapter I

SURVEY OF PREMISES AND DILAPIDATIONS. MEASURING-UP

WITH all but the smallest repair jobs a systematic survey of the premises and dilapidations should be made. This is essential for two good reasons: that nothing necessary shall be omitted, and that the information required for estimating and ordering material shall be properly obtained.

Failure to give satisfaction, defective repair work, losses through under-estimating, and failure to secure contracts are often due to the lack of a proper preliminary survey, and imperfect methods of estimating. The success of a jobbing builder specialising in repairs and extensions, and of men in charge of such work, depends on this complete and accurate survey.

THE SURVEY

There are two distinct parts to the survey:

- (1) Survey of the premises for the production of plans. This is necessary only in the case of alterations and extensions, and large repair jobs. In practically every job a sketch plan, drawn to scale, and with positions of principal features indicated, is very useful.
- (2) Survey of defects and dilapidations. This is essential on any job, small or large. It should be carried out by an expert who can tell by inspection what is necessary for each repair item, make the necessary measurements, and write down a full description. Rough sketches are often useful to illustrate the description.

The repairer should not commit himself to any estimate of the amount of work necessary or of the cost until he has made a proper survey. He may be pressed to give an approximate estimate, and with small simple items there may not be much risk in doing so, but generally he should insist on an opportunity of making a thorough survey and preparing a finished estimate. This may take some time, but it is the only safe and successful method.

A preliminary survey should be made, in order to form an idea of the extent and degree of difficulty of the work that has to be undertaken.

It is a mistake to take on any job for which the owner is not prepared to pay a fair price. Serious and extensive defects cannot be cured cheaply by quick and simple methods. The repairer should only undertake

work which he is sure will make a good job and give reasonable satisfaction. In this way he will avoid trouble afterwards, and gain a reputation for sound workmanship—the best business asset a repairer can have.

MEASURING-UP A BUILDING

Before proceeding further with the survey of defects, it will be useful to give some practical hints on measuring-up or surveying existing buildings, inside and out, including adjoining opening spaces, and drainage. Many good practical men have little knowledge of surveying beyond taking straightforward measurements with a two-foot rule and a tape. But there are many occasions when a sound knowledge of elementary surveying is very useful to the practical man. The chief principles are quite easy to learn, but care in taking and checking dimensions, and some practice, are necessary to give consistently reliable results. The inexperienced may gain valuable practice by measuring-up a small house and garden.

Instruments

A 2 ft. pocket rule; a 5 ft. flexible steel pocket tape, or a 5 ft. folding measuring rod; a good tape, either of linen or steel (a steel tape gives more accurate results but, must be kept dry and clean), 50 ft., 66 ft., or 100 ft. long; at least three surveyor's rods painted with red and white bands (they can be made quite cheaply out of square section 1 in. \times 1 in. stuff, or, better still, stiff round rods—one end should be pointed and preferably shod with a metal point; a good spirit level (a bricklayers' level) and a straight-edge board (for large important jobs a dumpy level on a tripod, with a telescopic measuring rod, is very useful); a dozen surveyors' steel arrows for marking the end of the tape when taking long measurements; a line (an ordinary bricklayers' line); pieces of chalk.

Outside Survey

To survey a rectangular site of moderate dimensions, and which is reasonably level, is quite a simple matter. As the angles are square (90 degrees), you simply measure the straight boundary lines. The tape measure should be used. If a 5 or 6 ft. rod is used small errors accumulate with each move. With a tape less than 100 ft. long it is convenient to measure a line in 50 ft. stages. The measurement commences at the end of the brass ring on the tape. If there are no fence posts or walls marking the extremities of the line, place steel arrows or wood pegs in the appropriate position. Use a steel arrow or wood lath to mark the end of each run of the tape. Take care that the tape is pulled straight and that the wind does not deflect it. Check all dimensions (that is, measure again after the first survey has been completed).

On sloping ground the tape must be held level. A line measured along the slope of the ground is longer than the level plan line, and a

SURVEY OF PREMISES AND DILAPIDATIONS

plan made from sloping measurements would therefore be inaccurate. An exception is when the length of a gradient is required—along a drain trench, for example.

Obtaining Angles

Boundary angles and wall angles of buildings may be greater or less than a right angle, though to a casual glance they look square. Any angle can be obtained by taking diagonal lines across the angle.

In Fig. 1, if two diagonal lines are set out and measured, and the boundary lines are also measured, the shape can be accurately set out to scale on paper and the angles so set out will be accurate, provided that careful measurements are made and the diagonals are straight and level. This use of imaginary diagonals is very important, as it provides a general check as well as giving correct angles.

Tie Lines

If it is impossible to set out diagonals from corner to corner of the site, owing to obstructions such as buildings or trees, the angles may be plotted from measurements of tie lines. Fig. 2 illustrates an example.

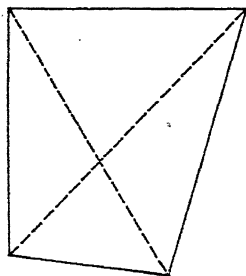


Fig. 1.—DIAGONALS.

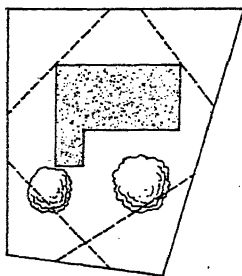


Fig. 2.—TIES.

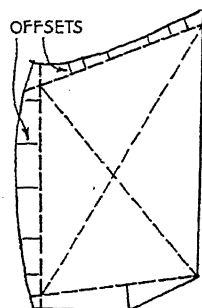


Fig. 3.—OFFSETS FROM RANGED LINES

Tie lines should be as long as possible and their points of intersection with the boundary should be measured from the corner.

Irregular Shapes

When the site has irregular winding boundaries, it is necessary to construct an imaginary framework within the boundaries (or without, if more convenient), and to take offsets at right angles to the framework lines to points along the boundaries, measuring the position of each offset along the line. Fig. 3 illustrates an example. Diagonals and ties are also measured.

Ranging a Line

To set out these imaginary lines for the purpose of obtaining

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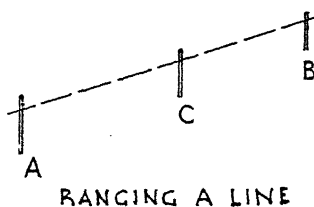


Fig. 4.—RANGING A LINE

measurements, it is necessary to range a line with rods, unless it is shorter than the tape length.

To range a line, fix the beginning and end, as in Fig. 4, *A* and *B*. Erect a ranging rod at each end, *A* and *B*. An assistant then takes a third ranging rod to a position roughly half-way between *A* and *B*, and holds it upright at arm's length from one side. The surveyor stations himself about a yard behind rod *A* and sights rod *B* at the opposite end. He then waves his hand to one side or the other to indicate to his assistant which way to bring rod *C* to line it with *A* and *B*. When the three rods are in line, rod *C* is driven into the ground. For a long line more than one intermediate rod may be necessary.

The ranged line can then be measured with the tape.

Measuring a Building of Irregular Plan

If any part of the building has an irregular plan, such as that in Fig. 5, the shape may be measured by taking offsets at right angles from a straight line, measuring the position of each offset from one end. In the street a straight kerb line will serve. If there is no existing straight line, range a line as described above. Ranged lines can be continued round the corners and ties set out and measured so that the correct angles can be plotted on paper.

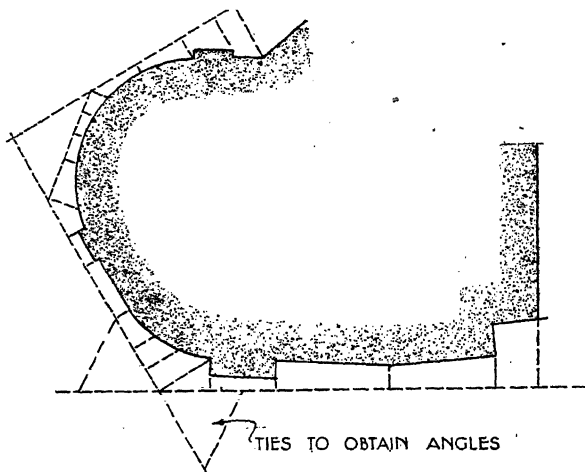


Fig. 5.—OBTAINING DIMENSIONS OF IRREGULAR PLAN BY OFFSETS FROM RANGED LINES

Inside Survey

The same method can be used inside a building. In old factories, for example, large areas of flooring are often enclosed by walls of irregular plan, and the method described will enable a plan to be prepared to scale.

The scale for preparing building plans should not be less than $\frac{1}{8}$ in. to 1 ft. For details 1 in. to 1 ft. is convenient.

Individual rooms should be measured along the walls above the skirting—on the plaster face. Door and window openings should be

SURVEY OF PREMISES AND DILAPIDATIONS

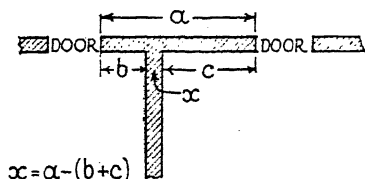


Fig. 6.—OBTAINING WALL THICKNESS "X"

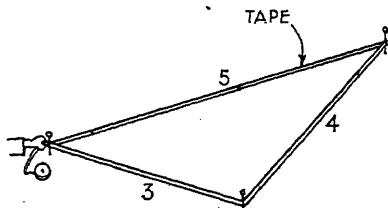


Fig. 7.—SETTING OUT A RIGHT ANGLE (PERSPECTIVE VIEW)

measured, and the width and projection of chimney breasts. Two diagonals from corner to corner will check the angles and dimensions.

Thicknesses of walls can be obtained from window and door jambs, making allowance for any plaster or rendering.

To measure the thickness of an interior wall having no opening, it is usually possible to take measurements on each side, as shown in Fig. 6.

Angles can sometimes be measured inside buildings with the aid of a two-foot rule fitted with protractor joint, which gives the angle in degrees of the rule adjustment.

Setting out a Right Angle

This can be done by two methods. The bricklayers' square can be used to set two lines at right angles. The tape measure can be used with three arrows or pegs to set out a right angled triangle by what is called the 3 : 4 : 5-rule, which means that if the tape is arranged as in Fig. 7 so that the two sides of the triangle are 3 ft. and 4 ft. respectively and the diagonal is 5 ft. then the angle enclosed by the junction of 3 and 4 is a right angle (90 degrees). Any multiple of 3 : 4 : 5 can be used—9 : 12 : 15, for example, in feet or yards, or any other unit.

Measuring Heights

Floor to ceiling heights should be measured in each room, and at two or more points along each corridor or large room. In old buildings floor to ceiling heights and floor levels are often found to vary considerably, and floor levels should be checked by using the spirit level and straight-edge.

A continuous run of floor to ceiling heights and floor thicknesses may be taken up staircase and lift wells, and also up exterior walls by the method shown in Fig. 8.

The floor to ceiling heights should be taken directly over one another. A straightedge levelled with the spirit level should be laid across the window-sills so that the two sets of measurements may be truly aligned.

Floor thicknesses may be measured at floor openings—staircase and lift wells. Variations of floor thickness may be met—these will be

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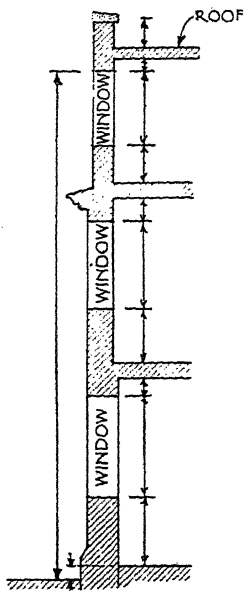


Fig. 8.—CHECKING HEIGHTS INSIDE AND OUTSIDE

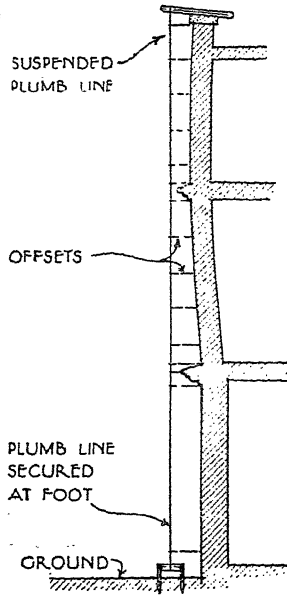


Fig. 9.—MEASURING BULGE FROM PLUMB LINE

revealed by corresponding variations in floor to ceiling heights below.

All beams and other important ceiling projections should be measured.

Measuring Elevational Projections

An elevation with complicated or extensive projections should have these projections measured directly or with the aid of a plumb rule or line. Level offsets are taken from the rule or line, and the heights at which they are taken are measured:

Cornices and mouldings may be measured in a similar way, though a special adjustable template is made for this purpose.

Walls which are out of plumb, leaning or bulging, also can be measured by taking offsets from a plumb line, as in Fig. 9.

Leaning spires and chimney stacks can have the out of plumb dimension measured by suspending a plumb line from the centre at the top. Let the plumb line come to rest, mark the point on the floor, and then fix it taut.

Measuring Elevations

Difficulty arises in gaining access to large elevations for measuring and inspecting defects. Ladders can be used on buildings of moderate size. A certain amount of access can be gained from upper windows.

Dimensions can be obtained by counting the courses of brickwork or masonry, if the work is in regular courses. Courses should be counted for heights and then measured in an accessible position. The number of bricks in a course can be counted for lengths.

If, for example, there are 133 courses of brickwork at 7 courses to 2 ft.,

$$\text{height in feet} = \frac{\text{Number of courses}}{\text{Courses in 1 ft.}} = \frac{133}{3.5} = 38 \text{ ft.}$$

A man of average height can reach about 7 ft. from the ground or floor, and using a 5 ft. rod or flexible steel tape can take vertical dimensions up to approximately 12 ft.

Photographs

In surveying large buildings, or elevations with complicated detail, it is a great help to take a few photographs. These can be enlarged if desired, and the enlargements form a valuable record of the buildings and their existing condition. On clear photographs many of the defects can be seen. This is of particular value, in conjunction with the surveyor's notes, when estimating for repairs.

LEVELS

Though the surveyor's level and staff is the best instrument for taking ground and floor levels, sufficiently accurate levels for our purpose can be obtained with the spirit level and straight-edge. The straight-edge should be a stiff well-seasoned board, at least 5 in. \times 1 $\frac{1}{2}$ in. in section. The way of using it is illustrated in Fig. 10, and is fairly obvious. The



Fig.—10.—TAKING LEVELS

difference in level is carefully measured, and then the straight-edge is moved along and re-levelled. On a long run great care must be taken or errors will accumulate. Mark each point with a piece of chalk at which the difference in level is measured, and take care to place the end of the straight-edge exactly on this point when the straight-edge is moved along.

Using a 10-ft. straight-edge the fall or rise can be booked as so many inches in 10 ft. Alternatively it can be taken as a ratio: 18 ins. in 10 ft. being booked as 1 $\frac{1}{2}$: 10. The latter is suitable for rather steep slopes.

In a similar manner gradients can be set out, but for all except short runs it is better to use boning rods.

Chapter II

INSPECTION, MEASUREMENT, AND ESTIMATING

THERE are several conditions under which a repairer may be called in to estimate for work. The chief of these are:—

(a) Small jobs of a specific kind; a few cracks in a wall, for example.

(b) Small jobs of a general character, such as damp walls or ceilings. In some cases general dilapidation.

(c) Work to be estimated for on a surveyor's Schedule of Dilapidations or Specification, and to be executed under his supervision, and completed to his satisfaction.

(d) Work to be estimated for on the basis of a District Surveyor's or Sanitary Inspector's List of Defects, a Dangerous Structure Notice, or other official notice, and to be executed primarily to satisfy the requirements of local or other authorities.

(e) Large jobs of a general character in which the repairer is required to estimate for repairing all defects, but without any exact specification of such defects.

(f) Alterations or extensions.

There are many variations of these conditions, but generally the work is either obvious by inspection or specified in a schedule or specification prepared by a surveyor, or is neither obvious nor specified. In the former case it is only necessary to confirm by inspection the work required, but in the latter the repairer must make a detailed survey and prepare his own specification.

A SYSTEM

It is essential for all but the smallest jobs to survey the defects by some system which will ensure that the building is thoroughly inspected and all defects investigated and measured. The following order of inspection does not pretend to include every item which may be met with, but if it is followed in the case of the average building the various items can be inspected and recorded in convenient groups.

This suggested order of inspection does not follow the system of trade headings, which is commonly used for new building work. It divides the building into main and subsidiary structural parts and equipment. In most cases this is the most convenient arrangement, though it does mix the trades to some extent.

SUGGESTED ORDER OF INSPECTION AND MEASUREMENT

Note.—A preliminary inspection should be made first. This gives a general idea of the layout, extent and condition of the building. If plans are available these should be examined. In some cases it is advisable to make sketch plans to scale, before commencing to measure the repair work.

It is generally convenient to inspect and measure defects on the outside of the building first, and then to take the inside. Ladders or other means of access must be provided if the task is to be done properly.

1. Site

Fences and boundary walls. Pavings, paths and drives. Type of sub-soil. Hoardings and enclosures. Watching and lighting. Space for unloading and storing materials. Water supply. Other preliminary items.

2. Demolition

Dimensions of building to be demolished. Materials—condition and value. Any materials which can be re-used in repairs. Any allowance required for materials. General requirements for demolition—hoardings, fans, shoring, derricks, cranes, and special plant.

3. Foundations and Excavations

It will be necessary to make trial excavations to inspect sub-soil and existing foundations. Nature of sub-soil. Condition of foundations. Underpinning. Basements. Strutting and sheeting trenches, etc. Pumping. Piling. Filling to levels with soil or hardcore. Consolidating or rolling. Plant required.

4. Scaffolding

Scaffolding, timber or tubular steel. Staging. Cranes. Derricks. Any special plant not otherwise recorded. Scaffolding and staging may be required inside as well as out.

5. Outside Walls

Existing materials and general condition—Bricks, stone, concrete blocks, mass or reinforced concrete, etc. Mortar. Pointing. Efflorescence. Decay of surface. Bond. Solid or hollow walls. Load bearing and non-load bearing walls. Type, extent, and area of defects. Damp-proof courses. Defects causing dampness. Defects causing structural failure—settlement, fracture, bulging. Damage due to bomb blast and bomb splinters. Shoring and strutting. Taking down dangerous or defective walls. Thickening old walls. Alterations or extensions and incidental works—cutting chases, toothing, cutting openings, etc. Building in new girders. Adding new piers. Cutting holes for pipes

and making good. Raking out and pointing for flashings. Bedding plates, templates and sleepers. Pointing round frames. Arches. Lintels. Steps. Chimneys, flashings and tops. Chimney pots and flaunching. Hacking key for renderings. Filling-in openings. Painting, distempering, whitewashing. Plinths, string courses, cornices. Condition of oversailing courses and cornices. Sills. Copings. Moulded, rubbed and gauged work. Carving. Terra-cotta, stone, precast or other dressings. Casings and protecting. Air bricks. Retaining walls. Boundary walls and piers. Piers and columns.

6. Inside Walls

Damp: saturation through wall; penetration through jambs and cracks; penetration through defective flashings; penetration through roof; penetration through faults in cavity walls. Condensation. Settlement and cracks. Settlement or movement of partitions and partition walls. Jambs and reveals. Air vents. Condition of surface. Defective plaster. Defective paint or distemper. Efflorescence. Alterations. Making openings. Building up openings. Cutting holes and making good. Pointing. Insulation. Cutting toothings and bonding in new work. New piers and columns.

Flues, hearths, and chimneys. Smoky flues. Grates, ranges and boilers.

7. Dampness

If this is a major defect the causes should be looked for through the whole structure. Dampproof courses. Walls. Jambs and reveals. Pointing. Frames. Renderings. Flashings. Chimneys and chimney flashings. Roofs and roof flashings. Damp or waterlogged site. Floors. Condensation.

8. Wall Linings. Ceiling Linings

Exterior—Renderings. Lathing. Sheeting—Asbestos-cement, corrugated iron, protected metal, weather boards, shingles. Flashings. Supporting framework. Efflorescence.

Interior—Plaster; lime, sand and hair. Hard plasters. Portland cement. Efflorescence. Paint, distemper, and wallpaper. Panelling. Solid wood, plywood, laminated board. Fibre board, plasterboard. Asbestos-cement sheets. Fire-resisting boards. Lincrusta. Lathings; wood laths, expanded metal, ribbed expanded metal and proprietary lathings. Holes and making good.

9. Pavings and Floorings

Exterior—Roads, drives. Paths. Terraces. Verandah pavings. Steps. Materials. Filling. Excavating. Levelling. Surface drainage. Weeds in paths.

Interior—Hard pavings. Concrete and reinforcements. Screeding.

Tiles. Clay, Terrazo, Quarry and other hard tiles. Granolithic. Black and white and coloured tiles. Jointless floorings. Skirtings. Covings. Internal and external angles. Borders and patterns. Rubber tiles and sheets. Damp and dampproofing. Sub-flooring. Surfacing and polishing. Asphalt. Cracks. Dusting-up. Settlement.

Wood boards. Timber joists. Battens and clips on solid sub-floors. Parquet floorings. Wood blocks. Plywood sheets and tiles. Proprietary composition materials. Shrinkage. Dampness. Dry rot. Settlement. Insulation and sound proofing. Dance floors. Floor ventilation.

Suspended concrete floors. Pre-cast concrete beams. Hollow pre-cast concrete and clay blocks. Fixing clips for wood batten floors and ceilings.

10. Decay of Timber

If this is a major defect the causes should be looked for throughout the structure. Dry rot. Dampness. Ventilation. Air bricks. Insects in timber. Dampproof courses. Damp ground under floors. Surface concrete. Roof coverings. Preservative treatment.

Decay may be found in floors, partitions, window and door frames, joinery, roofs, turrets, spires, beams, joists, pillars, trusses, rafters, purlins, studding, braces, frames, boards, skirtings.

11. Joinery

Frames. Doors. Windows. Pointing round frames. Butts and hinges. Rot. Painting. Loose knots. Shrinkage. Warping. Dowels. Shakes and other defects. Fixings. Wood plugs. Fibre and metal plugs. Other fixings. Brackets. Architraves. Mouldings. Picture rails. Skirtings. Shelves. Draining boards. Cupboards. Staircases; strings, newel posts, storey posts, treads, risers, blocks, linings, winders, spandril panels, balustrades, balusters, handrails. Solid staircases in concrete or pre-cast concrete with wood, marble, composition or other treads. Panelling. Matchboarding. Partitions. Window boards. Casings to beams. Casings to pipes. Roof lights. Glazing bars.

12. Pitched Roofs

Roof coverings; slating, tiling, lead, copper, zinc, flashings, bituminous felt, underfelt and sarking, shingles, thatch, corrugated iron, protected metal, asbestos-cement, etc. Ridges, hips, valley linings, eaves. Gutters. Roof structure; trusses, purlins, rafters, ridges, boarding, and fastenings. Insulation. Roof lights.

12a. Flat Roofs

Roof coverings; lead, copper, zinc, laps and rolls, bituminous felt, paving tiles, and other wearing surfaces. Gutters, outlets, parapets and railings. Ladders and access. Flashings. Insulation. Roof structure; joists, beams, strutting. Roof access. Roof lights.

13. Plumbing and Drainage

Sanitary fittings. Traps to sanitary fittings. Water supply. Taps and cocks. Joints. Pipes and accessories. Fixings; plugs, screws. Vent pipes, anti-syphonage pipes and traps. Pipe casings. Tanks. Overflows. Self-filling cisterns. Ball valves. Testing.

Soil and vent pipes, and joints. Rainwater gutters and pipes. Fixings and plugs. Gratings. Wire balls. Connections to drains. Testing.

Flashings. Flats. Aprons. Gutters in metal. Outlets. Ornamental lead, zinc and copper work.

Drainage. Materials. Land drains. Glazed stoneware drains. Cast iron drains. Joints. Concrete bedding and benching. Settlement. Connections. Ventilation. Access and inspection. Testing. Bends. Inspection and intercepting chambers. Connections to sewer. Gulleys. Syphons. Drainage of paved surfaces. Grease and petrol traps. Excavation and filling. Cesspools. Septic tanks. Separate drainage systems. Ventilation.

14. Painting and Decorating

Materials. Burning off. Chemical removers. Washing and rubbing down. Painting on exterior woodwork, renderings, metals, etc. Painting on interior woodwork, plaster, metals, etc. Painting pipes. Painting on brick, stone and concrete. Preservatives and stains. Staining, sizing, and varnishing. Signwriting. Notice boards. Gilding.

Paperhanging. Scraping off. Condition of plaster. Canvas coverings.

15. Glazing

Materials. Sheet glass. Plate glass. Wired glass. Curved glass. Special glasses for heat absorption, ultra-violet ray transmission, etc. Stained glass. Glazing bars. Leaded lights. Copper glazing. Putty. Roof lights.

16. Equipment and Fittings

Heating. Lighting. Cooking. Ventilation. Ironmongery. In a large building the various equipment installations should be inspected by an expert. Alternatively a list of faults should be made and submitted to the makers of the equipment for their comments. All locks, hinges, door and window fittings should be tested.

17. Alterations and Extensions

Plans required for all but smallest alterations and extensions. Survey. Materials. Existing structure. Sub-soil. Excavation. Foundations. Walls. Floors. Ceilings. Wall linings. Partitions. Roof and roof coverings. Heating. Lighting. Fireplaces, flues and chimneys. Doors and windows. Frames. Steps. Staircases. Fittings. Ironmongery. Painting and decorating. Prime cost sums.

Cutting openings. Building up openings. Lintels and bréssummers over new openings. Piers and stanchions. Steelwork or reinforced concrete. Roof trusses. Pads and templates.

18. Structural Framework

Carpentry. Timber framed buildings. Condition of joints and fastenings. Tests for settlement, plumb faces, and alignment. Steel framed buildings. Corrosion of steelwork. Fracture, cracks, settlement, and bulging of load-bearing brick and stone walls and piers. Roof trusses and beams. Lintels. Excessive deflection of lintels and beams.

19. Special Problems

In all large buildings there are special repair problems. Some of these are: Cleaning brick and stone walls. Painting on brickwork. Cleaning window and roof glass which has been neglected. Machinery foundations. Factory and warehouse floors for hard abrasive wear. Vermin infestation. Effects of overloading. Inadequate daylight. Unsuitable aspect of windows. Dusting-up of cement bound floorings. Fireproofing. Acoustic problems. Sound insulation. Thermal insulation. Heating and ventilation problems in connection with certain industrial processes. Provision of corridors, doorways, steps, hand rails, etc., in public buildings. Repair of buildings in a dangerous condition due to bomb or fire damage.

Where any such special problem is of great importance, the whole structure should be considered in relation to it. Many problems are connected with a desired reduction in maintenance costs. For example, reduction of heating charges by improving the thermal insulation of walls and roofs, and of lighting charges by enlarging window and roof light areas.

ESTIMATING

This is in itself a big subject and beyond the scope of this book. But a few hints on the special problems of estimating for repairs may be useful.

Estimating for repairs should be based on experience aided by records of previous jobs executed. There are four factors to each costing:

- (1) Labour.
- (2) Materials.
- (3) Overhead charges.
- (4) Profit.

Of these Labour is the most difficult to calculate. The cost of materials should be obtained from current quotations. The building trade weekly journals publish lists of current prices which are revised weekly, but these are for the London area only, and would be greater for small quantities. Laxton's Builders' Price Book is useful for examples of pricing, but the repairer's personal experience is the only safe basis.

Cost Analysis

Every operation should be timed and the material measured. An allowance for overhead charges must be added to obtain the true cost. To this the required profit must be added.

As an example, we may take the operation of inserting a dampproof course of two courses slates in cement mortar in an existing 9 in. wall. The brickwork to be cut out and the d.p.c. inserted in small lengths at a time. This is a typical analysis, though the quantities will vary with the type of wall:

Per Foot Run, 9 in. including waste:				£	s.	d.
Bricklayer and labourer, 1 hour @ 3s. 6d. ..	..	..	..	3	6	
5 bricks @ $\frac{3}{4}$ d. each .. .. .	..	..	..			4
1/10th cubic ft. cement mortar, 1: 2 mix @ 1s. cu. ft.	..	..	..			2
Slates (double course) .. .. .	..	..	..	1	0	
Net cost per ft. run				5	0	
10% for overheads and profit .. .. .	..	..	..			6
Gross price for estimate per ft. run				5	6	

This is the only method by which accurate records can be compiled as a basis for reliable estimating.

The nature of the existing work must always be carefully considered. Cutting holes or toothings in brickwork in hard cement takes much longer than such cutting in soft lime mortar, to give but one example.

In repair work, labour is often a much bigger cost item than materials. Guessing is dangerous, but there are occasions when an intelligent approximation of cost will have to be made.

Where existing work is cut into it must be made good on completion. Don't forget the cost of this. Small details must be taken into account. There is no short cut to costing and estimating.

Overhead Charges

Gross profit = net profit + overhead charges. The net profit is the amount left when everything is paid for. Overhead charges vary. They include all those extraneous items which have to be shared by all the work done, and include: Rent and mortgage repayments, rates, lighting, office heating and cleaning, insurances, stationery and office wages, wear and tear on plant, machinery and premises. In a small business the overhead charges may not amount to much, as the office work is done at home in the evenings—2% may cover it. In a large business it may be from 5% upwards.

Measuring the Repair Item

Many items are difficult to measure accurately. The case of a wall in which the facings have decayed is an example. The area of the wall

may be measured for re-pointing, and priced at so much a sq. ft. But it is difficult to estimate how many defective bricks will have to be cut out and new ones inserted. One method is to take typical areas and count the number of bricks to be taken out in a sq. ft. Taking several areas, average the number of bricks per sq. ft., and then the number of sq. ft. in the total area will give the approximate number of bricks.

Remember that when existing work is disturbed it may cause damage in the area concerned. The experienced estimator must include this in his original price. There are many such snags in repair work. In replacing a few slates on an old roof, for example, it may be found that the nails have corroded and half the slates will slip down as soon as the roof is touched.

Always make a thorough inspection. Tap the work with a hammer or mallet. Test fixings by pulling or pushing the fixed item. Test wood and plaster by sticking a penknife into them. In short, take nothing for granted.

Repairs Schedule Book

The survey of defects can be conveniently made in two column form, as follows:

Item

No.	Description.	Measurements.
1.	Chimney:—N.E. end, half-way down back of roof. Six flues as sketch plan. Re-point 4 sides in cement-lime mortar.	Approx. 4' 6" × 3' 4½" × 32 courses high on centre line (about 7' 6"). Remove about 24 bricks and replace with red pressed facings, 2¾ in.
	Bricks partly decayed.	
	Flaunching badly cracked.	Remove old flaunching and re-flaunch in cement mortar.
	3 pots cracked. Replace with new. Red 12 in.	3 new red 12 in. pots and set.

For small jobs it is convenient to have a third column in which the quantities can be worked out and priced. For larger jobs it is better to do this on separate sheets of paper ruled with quantity and cash columns.

Chapter III

SITES, SUBSOILS, FOUNDATIONS

MANY defects are due to unfavourable conditions in the site, subsoil, or general environment. Dampness, settlement, smoky chimneys, and decay of stone are a few examples. The site and its surroundings should, therefore, be examined as well as the buildings.

SUBSOIL

Faults in foundations, dampness, and inadequate surface drainage may often be traced to an improper construction in relation to the subsoil.

Waterlogged or very damp subsoil, such as occurs in clay basins, encourage the growth and subsequent decay of vegetable matter, and is liable to give off vapour which increases the risk of condensation within the building.

Low-lying ground is generally considered to be unhealthy. This is not necessarily so. If the subsoil is a deep bed of sand, or sandy gravel, good natural drainage is provided, but if it is impervious clay the water will lie on the surface unless a good system of land drainage is laid.

A common fault on sloping ground is the collection of water by natural drainage along the wall at the bottom of the slope. If the subsoil is clay and the water is not drained off, it soaks the soil around the wall foundation. The dampproof course should stop it rising up the wall, but it may rise through the underfloor concrete or through solid floors. This trouble may be cured by laying porous open-jointed land drains; or, if it is caused by water running over the surface, by laying a concrete surface gutter to catch the water before it reaches the wall.

Subsoil Types

The following descriptions of types and characteristics will be useful in the recognition and treatment of faults arising from subsoil problems:

LOOSE AND WEAK GROUND

There are several kinds of soil that are loose or weak. Alluvial soil, mud, loose sand, peat, silt, waterlogged ground near rivers and streams, and recently made ground are examples.

A weak or loose soil may be only a few feet thick and have a firm subsoil underneath.

Made ground, that is filled ground, is often unreliable, especially if

it is recent filling or consists of a mixture of soil, rubbish, ashes, etc. Some sites appear to be natural ground, but underneath a hollow or sand pit may have been filled and grass growing on the surface may obscure the filling.

Well consolidated filling which has settled for at least twenty years is reliable for load-bearing, provided the material does not contain offensive rubbish, such as vegetable matter.

Very loose ground tends to move when loaded. Loose sand is an example. Such ground is reliable if it is confined by sheet piling.

In mining areas serious site settlement is a risk.

SAND

This material varies greatly, depending on the comparative fineness and admixture with other materials. It provides good natural drainage, but fine sand is liable to movement, especially when subject to flooding, or containing underground streams.

Firm sand is an excellent subsoil, having good bearing value and good natural drainage. All sands are fairly easy to excavate, but trenches in all but the very firmest material must be strutted to prevent collapse.

SANDY GRAVEL AND GRAVEL

These are usually found in firm deep beds. They have high bearing value, good natural drainage, do not shrink or move, and are fairly easy to excavate. Shallow trenches do not require strutting.

CLAY

This material varies greatly. Provided that it is well drained it has good bearing value and is quite healthy, but if allowed to become saturated it is weak and most unhealthy. A basin-shaped site on clay is very troublesome as water drains down into it, and is difficult to dispose of. In wet weather clay becomes spongy, and during a dry spell shrinks so that fissures open to a depth of 2, 3 and even 4 ft.

Foundation bottoms within the shrinkage depth are liable to be disturbed. The walls may settle and crack from this cause.

CHALK

This is another material which has good bearing value when well drained, but is very weak when saturated. Dry, hard well-drained chalk is an excellent natural foundation on which footings can be built without concrete for all ordinary wall loads.

ROCK

All hard rocks have high bearing value provided that they contain no faults liable to settle under load. Fissures should be filled with concrete. Soft patches should be taken out and concreted. Though

costly material to excavate, foundations can be built on the levelled surface.

Bearing Values

The bearing values for various subsoils are given in the Data at the end of this chapter. They vary from about $\frac{1}{4}$ cwt. to 40 tons per sq. ft. Most subsoils will safely take the loads from ordinary walls if concrete is placed under the footings.

There are methods of testing ground for bearing value, but they are not very reliable. It is best to rely on experience and to study buildings in the district built on similar ground.

Trial Holes

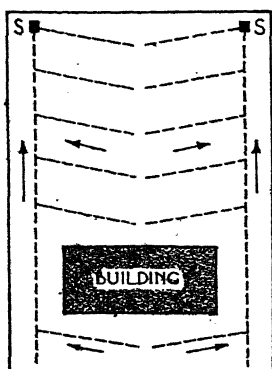
If taken at frequent spacings, trial holes give a reliable indication of the nature of the subsoil. A special auger may be used for this purpose.

SUBSOIL DRAINAGE

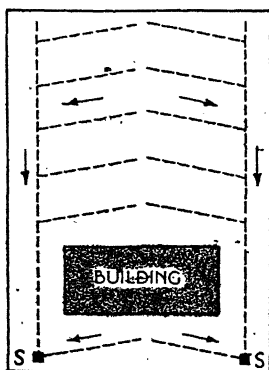
If settlement, dampness or other defects are due to very wet ground, some form of subsoil drainage is necessary to cure this condition. It is useless to repair defects without removing the cause.

Land drain pipes are porous and have open joints. They should be laid out to give equal drainage over the whole area. Figs. 11 and 12 illustrate typical layouts. They should be laid to even falls, not less than 1 in 40. The drains may be connected to ditches, streams, sumps, or sewers. Sumps are only suitable in porous subsoils, such as sand, chalk and gravel. If connected to the ordinary drains, the connection should be made at an inspection chamber (see Chapter XVI).

Trenches for land drains can be rapidly dug in ordinary ground with



LAND DRAIN LAYOUT FOR
FRONT TO BACK FALL.



LAND DRAIN LAYOUT FOR
BACK TO FRONT FALL.

Figs. 11 AND 12

a special long narrow trenching shovel. The land drain pipes can be rapidly laid with the aid of a pipe-laying tool. The drain pipes should be covered with stones for about 9 ins. The sump may be merely a deep hole filled with stones, or a brick chamber with outlet holes in the lower portion, and with stone filling outside and under the walls.

Subsoil drainage should not be overdone.

Many subsoils depend for stability on a certain water content. In some cities buildings have settled through subsoil shrinkage due to asphalt and other impervious pavings depriving the soil of water.

FOUNDATIONS

The concrete or other foundation under a load-bearing wall or column must spread the load over the subsoil so that the load per sq. ft. is within the safe bearing value of the subsoil (see page 23).

For moderate loads on subsoil of moderate bearing value, the foundation width and depth for ordinary mass concrete (1 : 2 : 4 mix) may be set out as illustrated in Fig. 13, top left. For heavy loads or weak ground special calculations are necessary, and it usually pays to have a reinforced concrete foundation.

The foundation bottom must be beyond the shrinkage depth due to the weather. In sand and gravel this is about 2 ft. In clay it may be 3 or 4 ft. If a foundation has settled or cracked from this cause it must be underpinned with concrete or brickwork to lower the bottom.

On weak ground, or ground of unequal bearing value, a reinforced concrete raft should be laid. The reinforcement should be placed near the bottom to take the tension due to bending should any portion of the ground settle and cause the raft to act as a suspended slab or beam. On soft or waterlogged ground reinforcement should be placed top and bottom to resist reversed bending.

Any concrete foundation should be reinforced on ground of unequal bearing value. This will prevent unequal settlement.

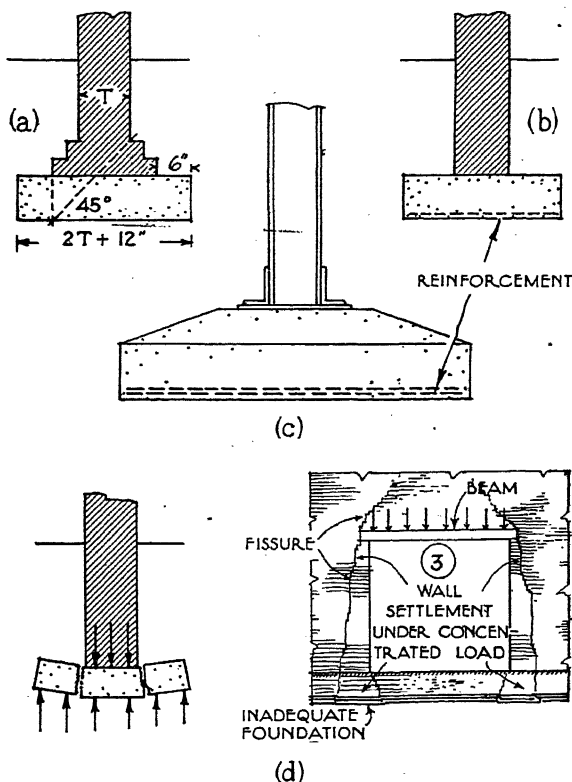


Fig. 13.—FOUNDATIONS (a) Standard setting out of wall foundation. (b) Reinforced concrete foundation. (c) Reinforced column foundation. (d) Fractured foundation.

Basements

In weak or wet ground these may be constructed of reinforced concrete in the form of a tank. The concrete should be waterproofed (see Chapter X). Double reinforcement is necessary to resist earth pressure.

Foundation Defects

Incorrect design resulting in fracture or unequal settlement. Poor quality materials resulting in decay. Movement due to soil movement. Movement due to soil disturbance. These foundation defects are responsible for other defects in the building, some of which may be remote from the cause. Fig. 13 illustrates various foundation types and faults.

Wall cracks, fractured dampproof courses with resulting dampness, wall bulging and distortion, and unequal settlement may be caused by defective foundations.

The load on the foundations should be uniform throughout. Heavy point loads on walls and piers, such as occur under beam bearings, should be spread by the foundation so that they are no greater than the adjoining wall loads. Unequal loading on the subsoil may result in unequal settlement of the walls. From this cause cracks, fissures, distortion, cracked ceilings, distorted frames, and even collapse may result.

Eccentric loading due to untied pitched roofs, vaults, arches, and wind pressure may cause heavy point loads.

Foundations near adjoining basements should be placed to avoid excessive pressure on the basement walls.

Piling

Where piling is necessary it is a job for a specialist. Square or round piles are used to support foundations where there is firm subsoil at a considerable depth with weak subsoil over it. Reinforced concrete piles are now extensively used. A reinforced concrete pile 14 in. \times 14 in. will carry up to 80 tons. The tops of the piles are connected with reinforced concrete beams. This forms the foundation for the wall.

Sheet piling is used to prevent lateral soil movement. As already explained, certain weak soils tend to squeeze out under load. Sheet piling may be of reinforced concrete or of steel with interlocking edges.

Old timber piles sometimes fail owing to the piles not being far enough into firm strata. Failure through rot is rare, except through rot near the top. Piles in river beds have been found well preserved after a hundred years of use. All timber tends to rot near the ground surface (see Chapter XII).

There are various piling systems. One well-known type consists of a steel tube driven down and then filled with concrete and reinforcement. With another system no great headroom is required for driving, and piles can be inserted inside existing ground floors and basements with hardly any disturbance of the structure, and no vibration. Specialist

firms can be relied upon to cure any form of foundation settlement by appropriate piling methods.

UNDERPINNING FOUNDATIONS

Where the defects indicate unequal settlement of foundations, or other foundation failure, it may be necessary to underpin the foundation in order to deepen it or to increase its bearing area.

In weak ground with a shallow foundation it may be necessary to take the foundation down several feet to a firmer subsoil.

The underpinning may be carried out in concrete or brickwork. In some cases the existing foundation consists of brick footings only, and it is then only necessary to add a concrete foundation a foot or two thick. In other cases the wall must be extended several feet below the existing foundation bottom to terminate in a new foundation several feet below.

Underpinning foundations may be fairly simple or very difficult, depending upon the load, depth, and condition of the subsoil. It may be necessary to underpin only short isolated lengths which have failed, or to underpin the whole of the foundations. The exact extent of the work can only be ascertained by uncovering the foundations and taking levels to find where settlement has occurred.

It may be necessary to shore the walls to ensure stability while the

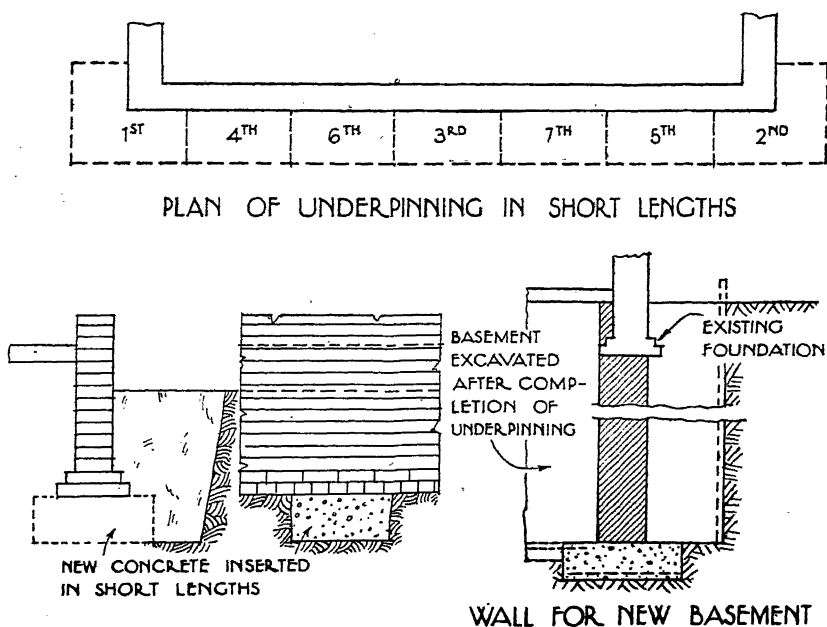


Fig. 14.—UNDERPINNING

underpinning proceeds. This depends largely upon the strength and condition of the walls and the depth of the underpinning. No risks should be taken.

Method of Foundation Underpinning

The foundation should be underpinned in short lengths. Excavate for this purpose in length of not more than 4 ft., as illustrated in Fig. 14. Strut the excavation as necessary. If it is a case of adding a new concrete foundation only, the concrete can be placed in position as soon as the ground is opened, using a rather stiff mix. The concrete will settle before it sets. When this has occurred the gap between the top of the concrete and the existing foundation should be made good by inserting slates in cement.

In the case of underpinning to build a new foundation wall, as is necessary where a basement is to be built under an existing building, the ground must be strutted, and the wall in most cases will require shoring.

The work should be done in the sequence shown in Fig. 14. Insert a length of underpinning at one end, then at the other, then in the middle, and so on, so that each section has time to set before an adjoining one is opened.

The use of rapid-hardening cement is advisable in some cases.

EARTH BANKS AND RETAINING WALLS

Earth may be banked at the angles given in the table Safe Loads on Subsoils. But rain and other disturbances may wear the soil away from the bank. Turfing will bind the soil and keep it in position. A rockery will serve the same purpose.

Terraces may be formed on sloping ground by excavating the high ground and throwing the soil into the low portion to level up. A bank or retaining wall should be formed to hold the earth back. If ballast is used, other than clean excavated soil, it should be dry clean material, not refuse liable to decay.

Where a steep bank is wearing or collapsing it should either be cut back to give a stable angle or a retaining wall should be built.

DATA

Soil Transport

						Cubic Yds.
Capacity of wheelbarrow	..	..	..	..	..	$\frac{1}{10}$
„ dobbin cart	..	..	..	..	..	$\frac{3}{4}$
„ small earth wagon	..	..	..	..	..	$1\frac{1}{2}$
„ large earth wagon	..	..	..	..	..	3
„ builders' cart	..	..	..	..	..	$1\frac{1}{2}$
„ light lorry ..	..	..	..	..	..	1

SAFE LOADS ON SUBSOILS

At a depth of 2 ft. from surface or beyond Shrinkage or Swelling due to varying weather conditions, whichever is the greater.

<i>Description of Soil.</i>	<i>Safe Load, Cwts. per Sq. Ft.</i>	<i>Approx. Angle of Repose, Degrees.</i>
Waterlogged mud, silt, loose sand, peat, etc.	½ to 5	—
Made ground, recent, consolidated	3 to 5	25
Made ground, old, well consolidated	5 to 10	30
Alluvial soil in river beds	1 to 10	—
River beds, firm	10 to 20	—
Compact earth	10	45
Clay, soft damp	10 to 20	20
Clay, damp but well drained	20 to 40	45
Clay, dry and well drained	40 to 60	30
Clay, London Blue, hard and dry	60 to 70	30
Sand, wet or loose	10 to 20	20
Sand, fine dry	20 to 40	30
Sand, coarse compact	60 to 80	45
Gravel, compact. Sandy gravel, compact..	80 to 100	45
Chalk, soft wet	10 to 20	25
Chalk, hard dry, well drained	80 to 120	45
Rocks, soft crumbling	20 to 30	45
Rocks, moderately hard	80 to 150	60
Rocks, hard	up to 800	90

The safe loads may be increased with the depth by adding to the above figures the weight of soil material excavated, measured from finished soil surface to bottom of excavation per sq. ft. of area.

1 cu. yd. = 27 cu. ft. = bushels.

Weights per Cubic Yard

	cwt.
Ashes	10
Earth mould	17
Cement	20
Marl	26
Sand	29
Clay	29
Coarse aggregate	30 (varies)

Concrete for Foundations, for 1 cubic yard

1 cement, 2 sand, 4 shingle =

Cement. Sand. Shingle. Weight cu. yd. as set.

Weight	.23 ton	.52 ton	1.00 ton	1.75 ton
Volume	.21 c. yd.	.43 c. yd.	.86 c. yd.	

Mass Concrete for Filling and Levelling, 1 : 10 mix.

Safe Depths for Excavations

Very firm subsoil	..	..	..	..	..	9 ft.
Moderately firm subsoil	..	..	..	..	..	3 ft. 6 in.
Loose subsoil	..	..	..	..	..	2 ft. 6 in.

Beyond these depths the sides must be strutted, and in loose subsoil sheeted.

Increase in Bulk of Excavated Soil

Loose earth and sand	..	..	..	..	..	10%
Moderately compact soil	..	..	..	..	..	15%
Close compact soil	..	..	..	..	..	20 to 25%

Chapter IV

DEMOLITION. SHORING

LARGE demolition jobs are best placed in the hands of firms specialising in such work. They can do the job at less cost and quicker than the ordinary builder, and they are familiar with the risks and the precautions necessary to obviate them.

The repairer will, of course, have to undertake small demolition jobs, and as he gains experience may safely undertake demolitions of moderate size. If he wishes to specialise in this work, he should employ at least one experienced man to supervise and instruct a team.

Demolition can be learnt only by experience, but the following practical hints will be useful, though every job must be treated on its merits. Most jobs have some peculiarity calling for special precautions or treatment. A careful inspection should be made and the method of demolition planned in advance.

SALVAGE

The salvage of materials and fittings should influence the manner of demolition. In old decayed or badly damaged buildings there may be very little of salvage worth, but in many buildings bricks, stone, timber, slates and tiles, metals, steelwork, doors, windows, sanitary and other fittings have considerable salvage value, and every care should be taken to prevent damage to all sound material.

If re-building or repairs to other buildings on the site are required, sound salvaged material may be re-used, and will save money.

Material should be sorted, cleaned and stacked as it is taken down. Bricks in lime mortar should be dressed and stacked. Bricks in strong cement mortar are very difficult to dress, but may be broken and crushed in a mechanical crusher to make dry ballast and coarse aggregate for concrete. All metals have good scrap value, especially lead, zinc, copper and bronze.

PRECAUTIONS

The demolition must be planned to prevent undue danger to the workmen and passers-by. If the building has been damaged or is badly decayed, measures must be taken to prevent premature collapse. If it is built tight up to adjoining buildings, or if only a part of the building is to be demolished, the building to remain must be shored or otherwise secured against the removal of support consequent on the demolition. Shoring is described later.

Measures must also be planned to make good any unavoidable damage to adjoining buildings, and to prevent dampness.

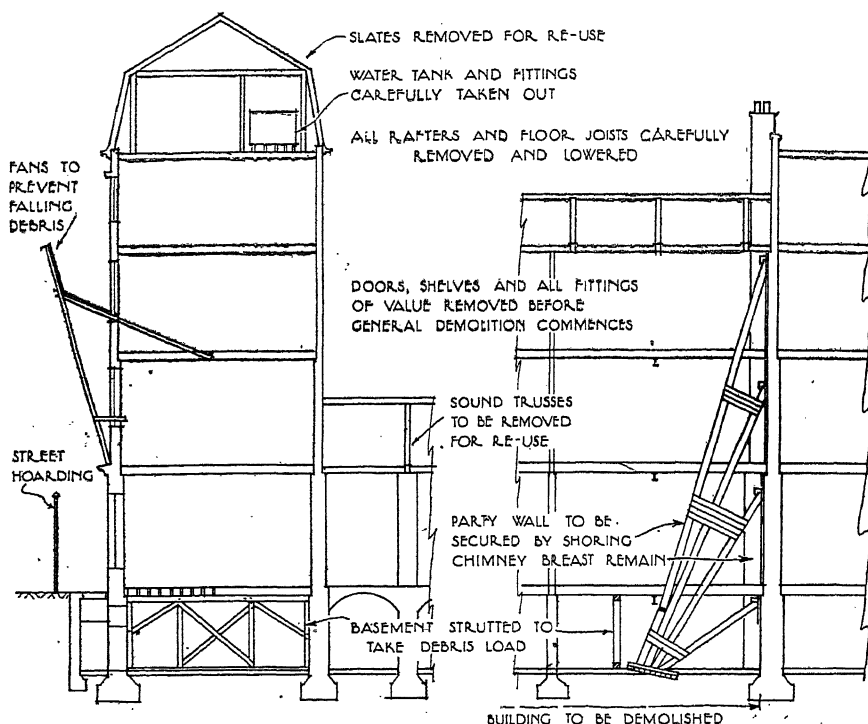


Fig. 15.—DEMOLITION FOR SALVAGE

The chief points to which attention must be given prior to demolition are illustrated in Fig. 15.

Demolition by Hand

The necessary shoring having been done, the front, or any boundary adjoining a public way, should be hoarded, and fans erected, as in Fig. 15. The fans must be arranged so that any material falling outwards is prevented from falling to the ground. They can be erected by placing scaffold poles through the windows so that the poles rest on the sill and are secured to the floor. Old timbers, if sound, can be used, and the inside ends can be nailed or lashed to the sides of the floor joists. Scaffold poles are then erected so that the bottom end rests on a cornice, sill, or other projection (with no suitable projection, a hole can be cut in the wall). These poles slope outwards, and are lashed or nailed to the upper poles, as shown in Fig. 15. Strong boards should then be secured to the fan thus formed.

The fans are erected first at or near the top floor. Demolition commences at the top, and the fans are removed and re-erected lower down as the building lowers.

The debris should fall within the building, and collect on the ground floor for ease of removal. The ground floor should be strengthened with boarding or planks. Any basements should be strutted, as shown in Fig. 15. All other floor boards should be removed, except for boards to form necessary walking ways. The debris then falls between the joists of all upper floors.

First remove all fittings of value. Usually walls should be demolished in small portions. Any large areas of walling brought down in one piece should be directed to fall outwards. Falling inwards they would either block the floors or smash through the joists and perhaps cause an unintentional and dangerous collapse.

Reinforced concrete floors must be broken up with pneumatic tools. The cost of breaking up reinforced concrete is rather high. Steelwork can be cut with oxy-acetylene apparatus.

On some sites it may be convenient to pull down a large area of walling by fixing chains or wire ropes round the portion and attaching the end to a lorry, which can then drive slowly ahead and pull down the wall. Plenty of space is needed for this purpose. The same method can be followed by using pulley block tackle so that a few men can exert considerable pull.

Explosives can be used in large demolitions to save labour, but this is a job for specialists only.

Buildings on columns can be demolished "in a heap" by strutting the lowest floor and then cutting through the columns. The strutting can then be knocked or burnt out. But this is a risky method, and it leaves the debris in an inconvenient tangled mass.

Any supported portion can be demolished by destroying the supports. While this is occasionally useful, care must be taken that supports are not accidentally removed or cut into.

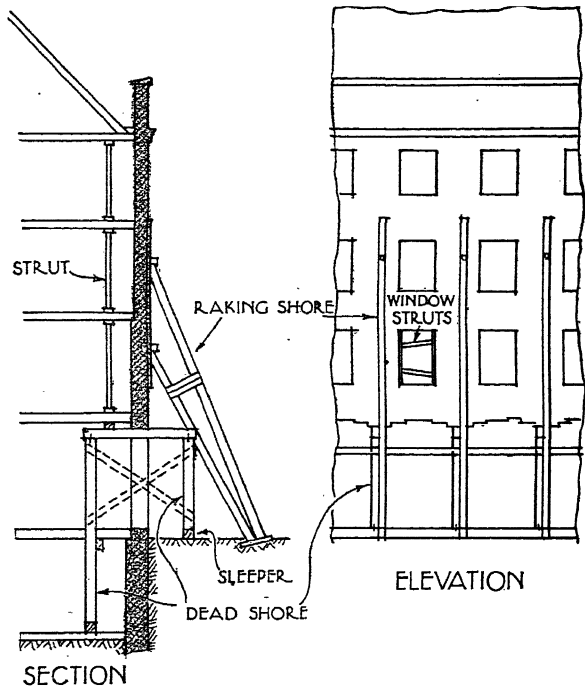


Fig. 16.—SHORING A BUILDING

SHORING

Temporary support can be applied to a building by raking, flying or dead shores. In many cases all three types are necessary.

RAKING SHORES

A raking shore is essentially an inclined strut placed against a wall to prevent it falling. Raking shores may be placed inside or outside, as the case suggests. They may consist of from one to four struts to each set, and should be placed at intervals along the wall—from 9 ft. apart upwards.

The shores exert a thrust on the wall, and should be so placed that this thrust is counter-balanced by a support on the other side. Otherwise, the shore might endanger the structure by pushing the wall inwards. The centre line

of the raker should intersect the bearing of a floor, as illustrated in Fig. 16. If there are no floors and the wall is a tall one, shores must also be erected inside.

A raking shore consists of the raker or

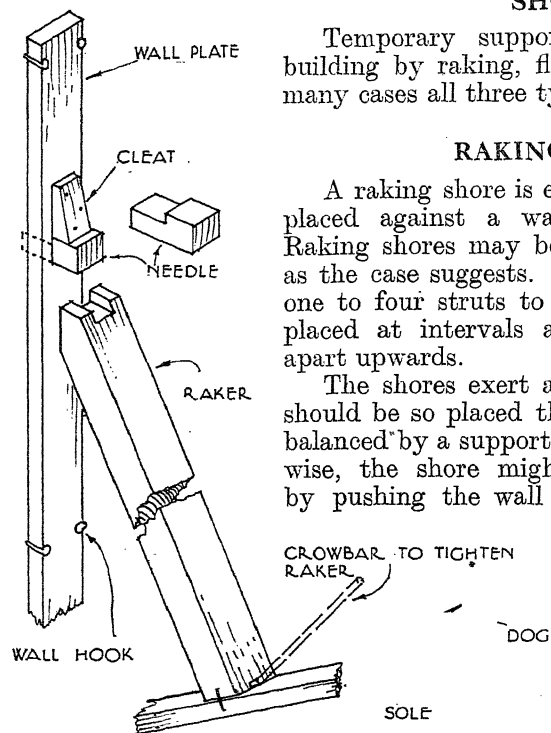


Fig. 17.—RAKING SHORE

rakers, the sole plate which provides a bearing on the ground, and the wall plate which spreads the thrust on the wall. The head of each raker is secured to the wall plate with a hardwood needle and cleat, as detailed in Fig. 17. Where necessary, folding wedges may be used to tighten the members.

Setting-out a Raking Shore

Select the positions for the sole plate on the ground and the needles on the wall. Put a peg in the ground and mark the bricks on the wall where the holes for needles must be cut. Cut these holes, and carefully measure the distance between them and set-out the same distance on the wall plate so that mortices can be cut to coincide with the holes in the walls.

With sufficient ground space, the lengths and bevels may be obtained by laying out the shoring members on the ground (laying them on their sides). Another method is to stretch a line from the sole plate centre to the needle hole centre—the line being the centre line of the raker. Lengths and bevels can then be taken, allowing for the thickness of

wall plate and sole plate. Still another method is to set out the shore to scale on paper.

The angle of the rakers depends to some extent on the space available. A reasonable angle is 60 degrees.

When lengths and bevels have been obtained, nail the cleats over the wall plate mortices and nail the top needle only in position. The wall plate can then be hoisted and fixed with galvanised wall hooks. The lower needles are driven into the wall (they should be a rather tight fit in the wall plate). Then bed the sole piece in position. The rakers can then be erected. They are tightened against the needles by using a crowbar to force the foot of the raker towards the wall an inch or two. The sole piece should be fixed so that the internal angle it makes with the raker is less than 90 degrees—the raker thus wedges against it as it is forced forward. Two iron dogs can be used finally to secure the foot. The sole piece must provide a good foundation, and if the surface soil is soft, let it down a foot or two into the ground. The sole piece and raker foot should be well soaked with preservative. For sizes of timbers see the data at the end of this chapter.

Multiple rakers should be braced together with boards, as shown in Figs. 15 and 16. Sets of rakers should be braced together by nailing boards to the backs of the outer rakers.

FLYING SHORES

Parallel walls with a gap between can be supported by flying shores, as illustrated in Fig. 18. As with raking shores, the thrust of a flying shore should be countered by the floors, roofs, etc., within the building.

There are various types of flying shore, the most common being that shown in Fig. 18. The principal member is the horizontal shore. Raking struts are supported top and bottom against straining pieces nailed to the horizontal member. Where the shores meet the wallplates, needles and cleats are used, as previously described, except that they are reversed in position for all but the upper struts. Folding wedges are used between the ends of straining pieces and struts to tighten up. For tall buildings, flying shores can be designed in several tiers.

DEAD SHORES

These are vertical shores, usually erected in pairs to support horizontal members called needles. The dead shores support walls while openings are cut in them, as illustrated in Fig. 16. A familiar example is where a shop front is inserted in an existing wall; another is where wide

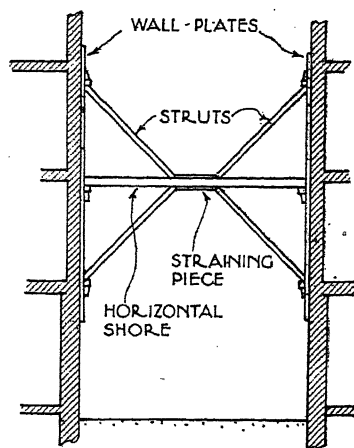


Fig. 18.—FLYING SHORE

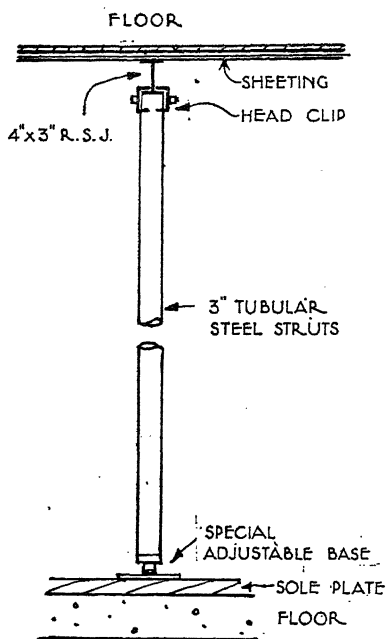


Fig. 19.—ADJUSTABLE STEEL STRUT

enables the new work to be executed in long lengths (compare with the method of underpinning in short lengths described in Chapter III).

STRUTS

Vertical struts between floors and ceilings are used to relieve walls of floor loads while alterations are carried out. They are wedged between sole and head plates, as illustrated in Fig. 16.

Adjustable steel struts, as illustrated in Fig. 19, are made which are easier to use than timber struts, and in the long run are less costly. They have various clip heads for use with steel or timber head plates.

Window Strutting

When large openings are being cut in a wall, the windows should be strutted, as shown in Fig. 16. This strengthens the wall and prevents distortion of the window frames. The cross struts are wedged against vertical jamb or reveal plates.

All shoring operations should be carried out with great care. Do not over-tighten the work, and avoid vibration. See that all thrusts are countered on the opposite side of the wall. Inspect at intervals and tighten loose wedges. Remove with care when the work is completed.

double doors are inserted in a factory or other wall.

For a wide opening, dead shore sets should be spaced at about 5 ft. centres—though each case must be judged on its merits. The shores should rest on thick sole pieces or heavy sleepers—taking care to provide a firm foundation. They are secured to the needles and sleepers with iron dogs.

When erecting dead shores, the vertical shores are first erected on the sleepers and temporarily strutted if necessary. The needles are then inserted through holes previously cut in the walls. The gap between needle and wall is filled with wedges, which should be just tight. Tall, dead shores may be cross-braced, and several sets of shores braced longitudinally.

Raking shores are often used with dead shores to secure the wall above.

Sets of dead shores may be used when underpinning walls to strengthen foundations or to build walls for a new basement under existing walls. This

DATA

Stacking Bricks

1 ft. cube = 10 to 15 bricks, according to size.

1 ft. cube = 100 to 140 lbs. (1 cwt. per ft. cube is a convenient average for calculations).

RAKING SHORES (Height from ground to top needle):

<i>Max. height ft.</i>	<i>Rakers ins.</i>	<i>Wall plates ins.</i>	<i>Ties and braces ins.</i>	<i>Sole plates ins.</i>
15	4 × 4	9 × 2	—	9 × 3
20	5 × 5	9 × 2	—	9 × 3

SINGLE SHORES:

DOUBLE SHORES:

20	5 × 5	9 × 2 or 9 × 3	6 × 1 or 9 × 1	9 × 3
25	6 × 6	9 × 3	9 × 1	9 × 3

MULTIPLE SHORES (3 or more rakers):

30	8 × 6	9 × 3	9 × 1	9 × 3 or 9 × 4
35	8 × 8	9 × 3	or 9 × 1½	11 × 3 or 11 × 4
40	9 × 9	9 × 3	—	11 × 4
50	10 × 10	11 × 3	—	11 × 4

NEEDLES: Hardwood, ex. 4 in. × 3 in. or 4 in., 3 in. to 4½ in. into wall.

Flying Shores

<i>Max. span ft.</i>	<i>Horizontal shore ins.</i>	<i>Struts ins.</i>
20	6 × 4	4 × 4
30	6 × 6 or 8 × 8	5 × 5 or 6 × 4

Dead Shores

Vary in size from 5 in. × 5 in. to 12 in. × 12 in., according to load and length or span. For heavy work calculations are advisable. Spacing of sets about 4 ft./5 ft. Height should in any case be limited to 25 times least width of shore. Needles must be stiff to avoid excessive deflection.

Struts

Struts usually 4 in. × 4 in. for heights of up to 9 ft. Plates at least 5 in. × 1½ in. Struts placed at intervals of from 4 ft. to 8 ft. about 1 ft. from wall.

Chapter V

WALLS—TYPES AND CONSTRUCTION

IN this chapter the various wall types and their functions are described. Some common faults of design and workmanship are also described, but consideration of decay, failure, and dampness are left to the two succeeding chapters VI and VII.

TYPES

Walls may be divided into the following functional types:—

1. LOAD-BEARING WALLS, PIERS AND COLUMNS.
2. CAVITY WALLS.
3. FRAME AND PANEL WALLS (NON-LOAD-BEARING).
4. PARTITION WALLS.
5. RETAINING WALLS.
6. BOUNDARY WALLS.

These functions are not always separated, but in repairing a building it is necessary to find out the chief functions of the various walls and partitions. This knowledge will assist in tracing faults and prescribing treatment.

LOAD-BEARING WALLS

This description applies to walls which carry structural loads—roofs, floors, beams, etc. The older buildings, with the exception of timber frame buildings, have load-bearing walls. The walls of many modern buildings are load-bearing—though generally confined to the smaller buildings.

The cross section, Fig. 20, illustrates a typical load-bearing wall suitable for a house. It is of solid brickwork $8\frac{1}{2}$ to 9 in. thick. Notice that the upper floor and ceiling joists are built 4 in. into the wall, and rest on an iron-bearing bar. Timber bearing or wall plates were formerly used for this purpose, but timber plates are not now allowed to be built into walls as they tend to rot and endanger the stability of the structure. In some buildings the timber joists rest direct on the brickwork, but an iron-bearing bar gives a level bearing and helps to spread the load.

Dampproof Course

This is a course of impervious material placed in the wall to prevent the passage of moisture. A dampproof course (hereafter referred to by the initial letters d.p.c.) should be placed horizontally in all walls in contact with the ground to prevent damp rising up the wall. This d.p.c. should be at least 6 in. above the ground level adjoining the wall

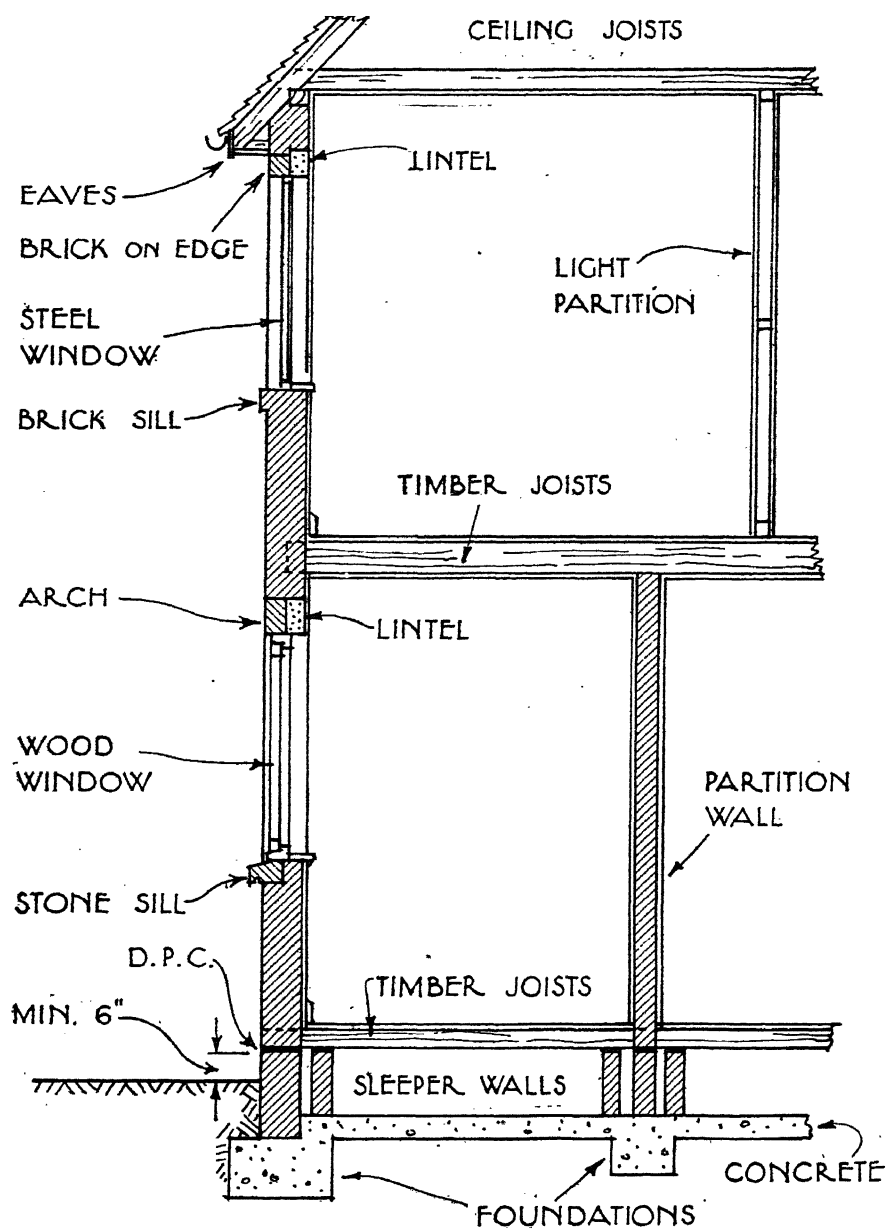


Fig. 20.—CROSS SECTION THROUGH BUILDING WITH LOAD-BEARING WALLS

face, as shown in Fig. 20. If it is much lower rain may splash from the ground or paving and soak the wall above the d.p.c., or soil may be dug and raised above it.

Dampproof courses should also be placed in parapet walls, just above the roof, and in chimneys, to prevent rainwater soaking down.

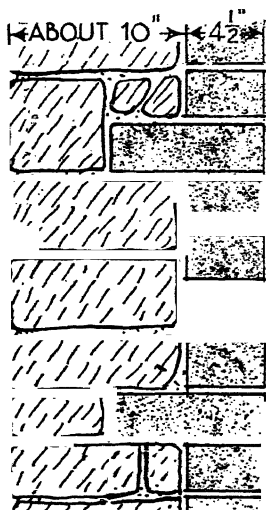
Vertical d.p.c.s are used to make basement and other walls damp-proof where water is liable to soak the wall from outside.

The following are the principal dampproof course materials:

Natural slates of best quality bedded in Portland cement and sand (mix 1 cement : 2 clean sand). Two courses are usually adopted, laid to break joint. Faults may develop in such d.p.c.s if the mortar is allowed to dry too quickly and so form shrinkage cracks. Unequal settlement may fracture the slates.

Impervious "engineering" bricks, such as Staffordshire blues, make good d.p.c.s with two or more courses laid in cement mortar. Faults may be due to the use of a few cracked or faulty bricks, mortar shrinkage, or an absorbent mortar.

Waterproofed cement (incorporating a proprietary waterproofer) makes a good d.p.c. provided that shrinkage cracks are avoided. It may crack under unequal settlement. Though not much used for horizontal d.p.c.s in new walls, it is frequently used for vertical d.p.c.s and for dampproofing old walls.



RUBBLE WALL IS
BEST WITH BRICK
BACKING

Fig. 21.—STONE RUBBLE WALL
WITH BRICK BACKING

Bitumen sheeting and bitumen impregnated felts are used in various forms of proprietary d.p.c.s—these are made in the usual wall widths. They are supplied in flexible rolls, and are rapidly laid. Joints are sealed in mastic. These d.p.c.s are durable, but may be perforated by sharp tools, grit, or rough usage before laying.

Asphalt, a bituminous product, is a good d.p.c. It is applied hot and floated over the wall. Under heavy loads it squeezes to some extent, and is chiefly used for vertical d.p.c.s between two brick "leaves," and also as a d.p.c. in parapet walls—in the form of a continuation of the asphalt roofing.

Lead and copper are good d.p.c. materials, but may be corroded by chemicals in the mortar.

Lead covered with bitumin—a type of proprietary d.p.c. is durable and largely used in modern buildings.

On rising or falling ground horizontal d.p.c.s are often stepped. Care must be taken to make waterproof junctions between the horizontal and vertical portions.

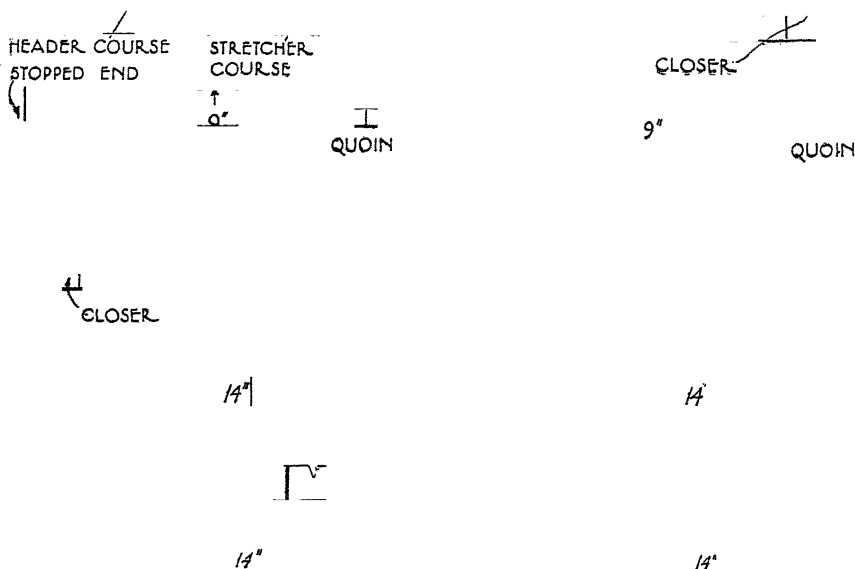


Fig. 22.—ENGLISH BOND

Fig. 23.—FLEMISH BOND

Composite Walls

The inner and outer thicknesses of a wall may be of different materials: Stone backed with brick or brick backed with concrete. The two materials should be properly bonded together, otherwise the facing tends to separate from the backing. See Fig. 21.

Brickwork Bond

This is an overlapping of the bricks or blocks. The strength and appearance of the wall is largely decided by the bond.

The chief bonds in brickwork are: English—a course of headers alternating with a course of stretchers, as in Fig. 22. Flemish—a header-stretcher sequence in each course, as in Fig. 23. Flemish Garden Wall—one header to three stretchers in each course. Three-and-One—three courses of stretchers to one course of headers, as in Fig. 24. Three-and-One bond is largely used in modern work as it is economical in facing bricks, and sufficiently strong for most load-bearing and other walls. English bond is the strongest and Flemish bond the best looking.

In repair work always preserve the existing bond, and match the colour of facings as far as possible.

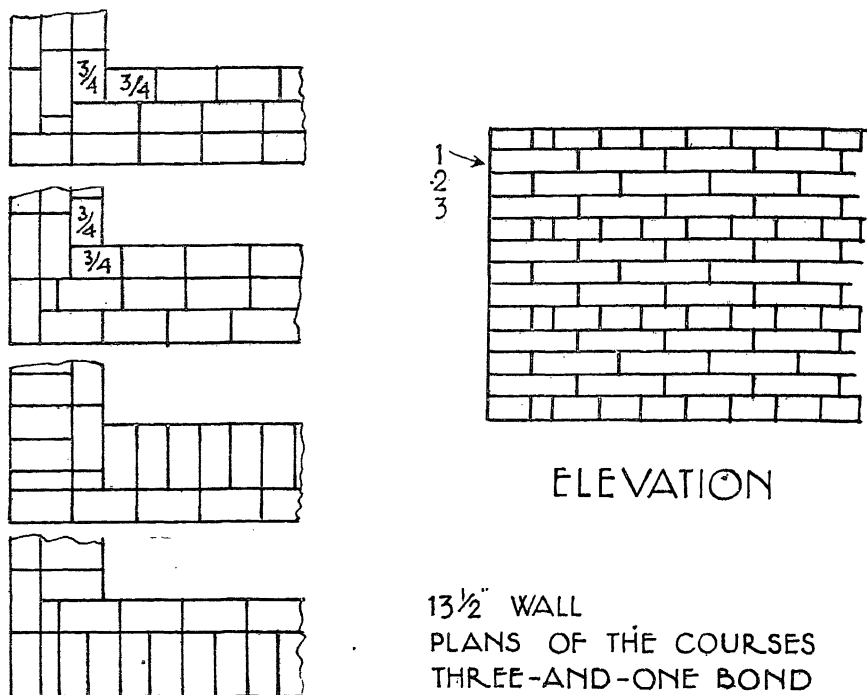


Fig. 24.—THREE AND ONE BOND, OR ENGLISH GARDEN WALL BOND. ECONOMICAL IN FACINGS, OF ADEQUATE STRENGTH FOR ALL ORDINARY WORK, IT IS WIDELY USED

Masonry Walls

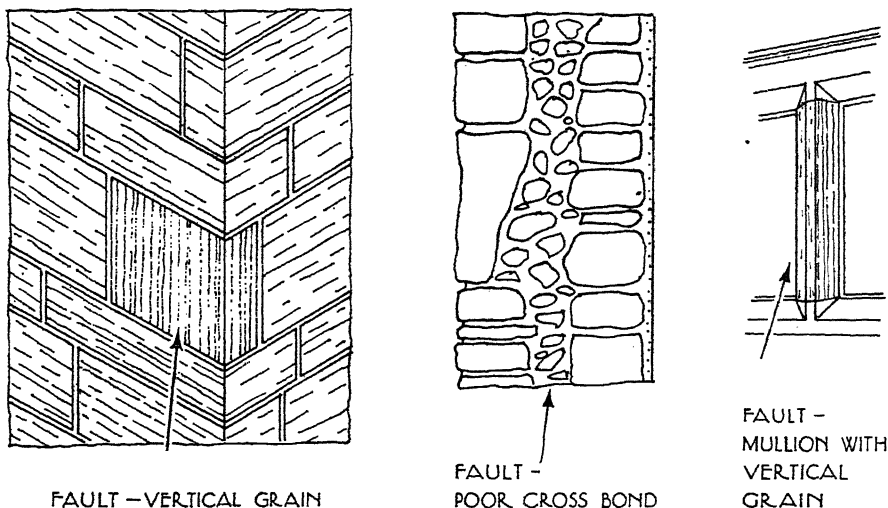
Stone walls are classed according to the general shape and tooling of the stones. Rubble walls are built of only slightly prepared stones, as illustrated in Fig. 26. Rough rubble is weak, though such walls are often of considerable thickness. Coursed rubble is stronger in bond than random rubble. Ashlar masonry consists of carefully prepared rectangular blocks consistently bonded.

In repair work it is important to identify the type of masonry, bond and stone, and to match in the repairs.

Stone has a "grain"—a strata formation indicated by straight lines or layers. In walls it is most important that this grain should be horizontal. If laid with the grain vertical, the block tends to split and decay. This point is illustrated in Fig. 25.

Rubble walls often have a hearting of small stones in mortar or grout. Large stones should bond through—about one to every square yard—for strength. Fig. 26 illustrates the fault of lack of transverse bond.

Stone mullioned windows should have the mullion stones cut from a deep bed so that the grain is horizontal. The fault of vertical grain,



Figs. 25, 26 and 27.—FAULTS IN MASONRY

as shown in Fig. 27, is sometimes found, and is the cause of decay and failure.

The voussoirs of stone arches should have the grain at right angles to the thrust.

CAVITY WALLS

This is a form of dampproof wall construction in which the outer walls are built in two separate leaves connected across the cavity by ties which are so designed as to prevent water creeping across.

Fig. 28 illustrates a typical cavity wall for a house. Cavity walls often fail to keep out damp owing to faulty construction. The following points should be carefully watched in building them, and in repairs the faults indicated should be looked for (see also Chapter VII).

(a) The ties must be kept clear of mortar droppings, otherwise moisture will creep through the mortar to the inner wall. A batten attached to lines should be laid over each course of ties to catch the droppings. It can then be raised and cleared. Even so, a few droppings may catch on the ties. These should be cleared from above and allowed to fall to the bottom of the cavity.

(b) The cavity should continue downwards past the d.p.c., and the d.p.c. should be in two separate widths, as shown in Fig. 28. Any mortar droppings falling to the bottom of the cavity will do no harm provided they do not rise to the d.p.c. level.

(c) Door and window openings must be provided with vertical d.p.c.s at the jambs, as shown in Fig. 28. If the jamb is formed in brickwork without a d.p.c. water will soak through (this fault is quite common in cavity walls built many years ago).

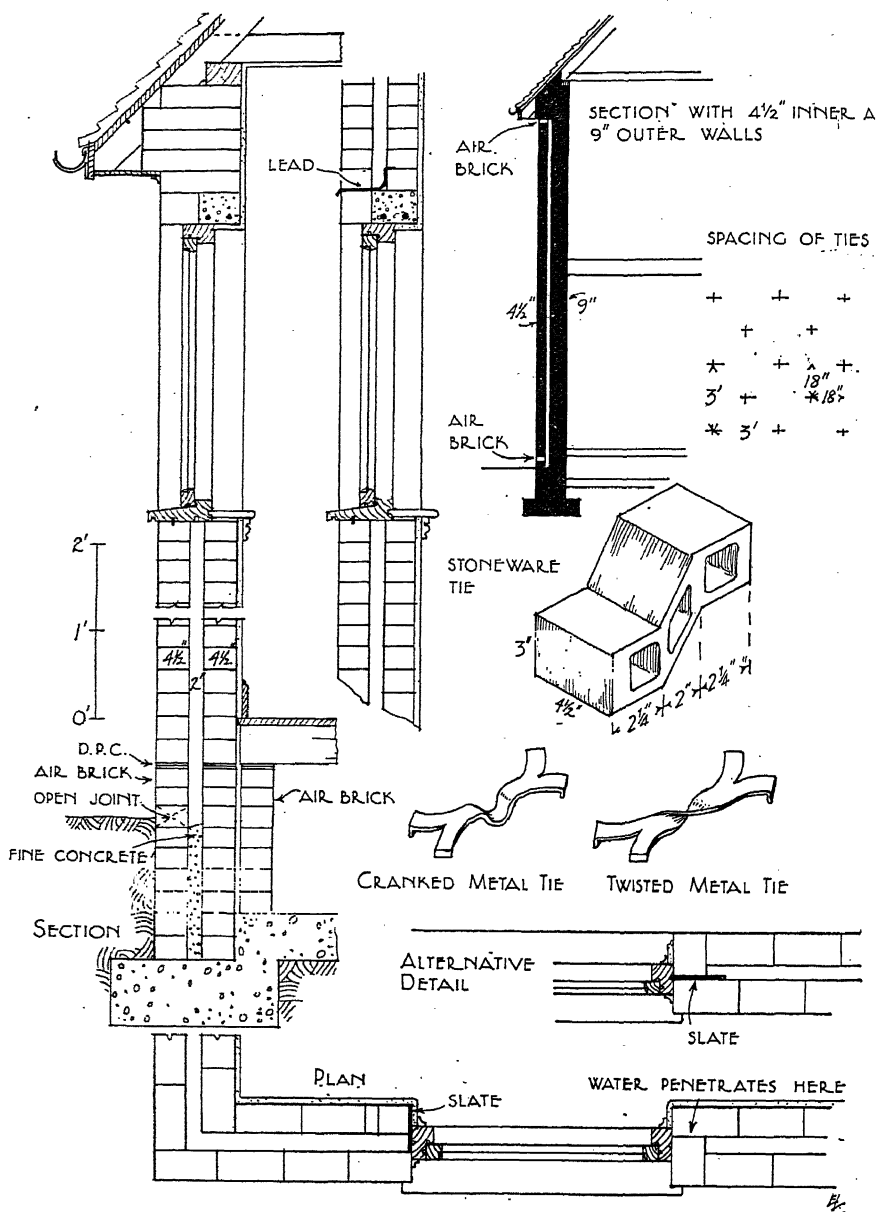


Fig. 28.—CAVITY WALLS

(d) The head of the door or window must be protected by a lead or other flexible d.p.c. stepped up the back of the cavity and tucked in a bed joint of the inner leaf, and turned over the arch or head of the front leaf, as shown in Fig. 28. This prevents water soaking into the front leaf and passing through the arch or lintel to the inner leaf. This d.p.c. should project 6 in. each side of the opening.

(e) The cavity should be drained by leaving open joints as weep holes at the foot. This allows moisture penetrating the outer leaf to run down to the bottom and drain away. Air bricks top and bottom assist drying, but reduce the thermal insulation of the wall—they are not essential in most positions.

(f) At eaves level the wall should be built solid. The projecting eaves prevent water soaking this solid portion.

(g) Parapet walls with copings may be built solid or hollow, but a d.p.c. must be placed just above roof level. This should be a continuation of the roof covering after it is turned up the parapet wall.

(h) Ties should be in courses 3 ft. apart horizontally and 18 in. apart vertically. They should be of galvanised iron or glazed stoneware, though the latter is rarely used.

(i) Tall gables should be strengthened with a pier or transverse partition wall in the middle.

SLEEPER WALLS

These are low walls which are built under ground floors to support timber or other floor joists. A timber or iron-bearing plate may be placed on top to give a level bearing. A d.p.c. should be placed on top of the sleeper wall under the plate or joists. See Figs. 20 and 28.

Sleeper walls are honeycombed with openings so that the floor may be ventilated, as described in Chapter X. For lightly loaded floors the sleeper walls are $4\frac{1}{2}$ in. thick, and are built direct on the surface concrete.

Fender Walls

These walls enclose the solid hearths, and in timber floors form a bearing for the ends of the joists.

CONCRETE WALLS

These may be of mass concrete poured into shuttering, reinforced concrete, pre-cast concrete hollow blocks, or pre-cast concrete slab or panel units.

Mass concrete is liable to develop crazing and even open cracks due to shrinkage. Reinforced concrete does not usually develop cracks as the steel reinforcement takes the stresses due to shrinkage. Modern houses in reinforced concrete have been built with outer walls only 5 in. thick, with insulating material inside.

Unsuitable aggregate is a cause of concrete failure. For outside walls, or wherever moisture is present, only clean brick, stone, or gravel

aggregate should be used. Breeze may contain partly burnt coal which will expand in contact with moisture and disrupt the concrete.

FRAME AND PANEL WALLS

With structural loads carried by a frame of steel or reinforced columns and beams, the walls do not carry loads. They are merely panels in the frame, though they may project on the outside face of the frame members and present a continuous surface which conceals the frame. Any modern building with brick or masonry walls should, therefore, be carefully examined to find out whether it is framed or has load-bearing walls.

The walls may stand on beams or on the edge of the reinforced concrete floors (which are sometimes combined with an edge beam). These floors are often continued through the wall and project as a lip or cornice. Trouble may arise at this point through water soaking through into the floor.

Some frame buildings are not walled with brick or masonry, but are sheeted with asbestos-cement, corrugated iron, protected metal, or other waterproof sheeting. Unless special measures are taken by lining the inside face with insulating material, such walls make the interior very hot in summer, and are the cause of high heating costs in winter. For insulation methods see Chapter XV.

As the walls and partitions of frame buildings are comparatively thin, and the frame readily transmits vibrations set up by sound waves, excessive noise transmission is often a fault in such buildings. In a new building special measures can be taken to insulate the frame connections, stanchion bases, wall and floor bearings (see Chapter XV). The fault is not easily remedied in an existing building.

PARTITION WALLS AND PARTITIONS

Partition walls are interior walls bearing loads from floors, ceiling or roof. They are usually of brick, or concrete blocks, or concrete, and are built on foundations.

Partitions are usually of light construction as they are not intended to bear loads. Cellular bricks, hollow blocks, breeze and lightweight concrete, plaster slabs, and various kinds of sheeting or boarding on timber or light steel frames, are the chief partition materials. Thin glazed and sheeted partitions are also used for forming cubicles and sub-dividing offices, etc.

In repairs and alterations it is important to distinguish between load-bearing partition walls and partitions. If a load-bearing partition wall is to be removed arrangements must be made to carry the load above. A partition bearing no load can be removed without affecting the structure.

RETAINING WALLS

Walls retaining earth should be designed in relation to the load and height. Where the earth is level on top a wall with a slight batter and

not more than 3 ft. high from lower ground level may be $13\frac{1}{2}$ in. thick if of good bricks in cement mortar with a concrete foundation 2 ft. below lower ground level. Weep holes should be provided for drainage.

Old retaining walls in lime mortar sometimes fail owing to decay of the joints. Bulging and cracking are due to insufficient thickness.

In retaining high ground reinforced concrete retaining walls are less costly than mass brickwork or masonry.

BOUNDARY WALLS

Though more costly than fencing, brick, concrete or stone boundary walls require very little maintenance, provided the materials are hard and durable. There should be adequate piers at intervals of 10 to 15 ft., and a good foundation should be provided. Heavy piers should be provided at gateways.

Failure and defects are usually due to inadequate foundations and decay of pointing. A d.p.c. should be provided 6 in. above ground level to prevent damp rising, and the top should be protected by a weathered coping.

Where the lower part of a boundary wall retains earth, the thickness should be increased accordingly.

DATA

Strength

Thicknesses as for dwellings and buildings of the warehouse class as required by by-laws may be obtained from the local surveyor. Loads met with are usually well within the safe loads for bricks of moderate quality.

Example:—

Fletton and wire cut bricks with a crushing strength of 4,000 lbs. per sq. in. in a mortar of 1 cement to 3 sand will take a maximum pressure of $13\frac{1}{2}$ tons per sq. ft. for a slenderness ratio not exceeding 6 (slenderness

$$\text{ratio} = \frac{\text{height}}{\text{least thickness}}).$$

The slenderness ratio of piers should not be greater than 12.

Quantities

The unit of measurement of brickwork is the ROD.

- 1 rod = 272 ft. super. of $13\frac{1}{2}$ in. brickwork ($1\frac{1}{2}$ bricks thick);
- = 408 ft. super. of 9 in. brickwork (1 brick thick).
- = 816 ft. super. of $4\frac{1}{2}$ in. brickwork ($\frac{1}{2}$ brick thick);
- = $306\frac{1}{4}$ cu. ft.;
- = $11\frac{1}{3}$ cu. yds.

Number of bricks required

2 $\frac{3}{4}$ in. bricks, $\frac{3}{8}$ in. bed joints.				
1 rod brickwork, 13 $\frac{1}{2}$ in. thick	..	..	..	4,120
1 yd. super. 9 in. thick	..	..	..	94
1 yd. super. 11 in. cavity wall	..	..	..	94
1 yd. super. 4 $\frac{1}{2}$ in. thick	..	..	..	47
Add for waste.				
1 yd. super. facings only in English bond,	72 bricks.			
1 yd. super. facings only in Flemish bond,	63 bricks.			

Weight of Common Brickwork

In lime mortar	..	..	about 112 lbs. per ft. cube.
In cement mortar	..	..	about 115 lbs. per ft. cube.
330 bricks, 2 $\frac{3}{4}$ in. thick, to 1 ton (approx.).			

Mortar required for $\frac{3}{8}$ -in. joints

1 rod brickwork, 13 $\frac{1}{2}$ in. thick	..	..	..	2.5 cu. yd
9 in. brickwork, 1 yd. super.	..	..	..	.05 "
4 $\frac{1}{2}$ in. brickwork, 1 yd. super.	..	..	..	.02 "
Pointing, per yd. super.	..	..	..	.2 cu. ft.

Chapter VI

WALLS—MORTARS. DECAY OF MATERIALS

THE reader should refer to the preceding chapter for wall types and faults of design, and to the succeeding chapter for damp walls. The defects found in walls are generally attributable to one of the following main causes:

- (1) Faulty design.
- (2) Unsuitable materials.
- (3) Frost.
- (4) Action of salts in the materials.
- (5) Neglect (e.g. neglect of pointing).
- (6) Action of polluted atmosphere.
- (7) Mechanical failure through settlement and side thrusts.

In this chapter we are concerned with the decay effects of these unfavourable factors on the following wall materials and systems:

- (a) BRICK.
- (b) NATURAL STONE.
- (c) PRE-CAST ARTIFICIAL STONE.
- (d) TERRA-COTTA AND FAIENCE.
- (e) SLAB FACINGS.
- (f) CONCRETE AND CONCRETE BLOCKS.
- (g) SHEETING AND FRAMING.

DESIGN AND MATERIALS

Faults in design are described in Chapter V. The cause of such faults must be traced and rectified before the defect is repaired. It is useless to repair and leave the cause untouched.

Generally, the same materials should be used in the repair. But if the original materials are unsuitable for the atmospheric or other conditions, the problem of re-facing or rendering must be considered.

Walls exposed to the weather must be built of durable materials if they are not to give trouble. Bricks must be well and evenly burnt right through. The best common bricks are durable. The worst break up within a few years.

Natural stone varies in its resistance to weather and atmospheric pollution. If a stone decays rapidly it is useless to replace with the same material, unless the wall face can be cleaned at regular intervals. Preservative treatment does not last long—surface cleaning by washing or steam treatment is the only way to fight chemical attack from a polluted atmosphere.

Mortars

The use of a strong cement mortar is rarely advisable in repair work. It tends to shrink away from the brick or stone, and so open fissures which cause dampness. As Portland cement contains soluble salts the greater the cement content of the mortar the greater the risk of efflorescence (white salts deposited on the surface).

The strength of the mortar should be about the same as that of the brick, stone, etc. Where a strong cement mortar has been used in re-pointing old brickwork it has been found that the surface of the brick breaks up.

Lime mortars are quite good if properly made, though, in an exposed position, lime mortar pointing is affected by rain and frost. A lime-cement mortar is best for ordinary work—it is fairly strong and durable, adheres well, and works easily off the trowel. It can be used for both laying and pointing. The following mixes are suitable for bricks of medium strength. For soft or old bricks the mortar should be weaker.

Mortars for Brickwork of Medium Strength

1 part lime : 2 parts cement : 9 parts sand, using a non-hydraulic lime hydrate or putty. Hydraulic lime should not be used with Portland cement.

1 part cement : 4 parts sand. Quite strong enough for bricks of moderate strength and walls moderately loaded.

Hydraulic lime mortars are good if the lime is slaked to the maker's instructions—1 lime : $2\frac{1}{2}$ to $3\frac{1}{2}$ sand.

The above mixes are approximately those recommended by the Building Research Station, and I have found them excellent in use, provided they are selected with proper consideration of brick strength and position of wall.

Mortars for Stone of Ordinary Strength and Density

For ordinary natural stones it is a mistake to use a very strong mortar. The following is suitable:

1 cement : 3 lime putty or hydrated lime : 12 crushed stone (by volume).

The Society for the Protection of Ancient Buildings recommend a lime-cement mortar, as follows:

1 lime : 6 sand. This should be knocked up with Portland cement in the proportion of 1 cement : 6 mortar.

A new silica mortar for use with stone is said to avoid all harmful action so that it can be safely used for repair work. It is composed as follows:

1 part silica flour to 1 part clean coarse sand with No. 4 Silicaseal solution.

Experience is, of course, a good guide in selecting a mortar mix for a particular purpose, but the above mortars will suit most cases.

Mortars for Cast Stone

Lime-cement mortars of moderate strength are recommended by the Cast Concrete Products Association.

1 cement : 4 hydrated lime : $2\frac{1}{2}$ to $3\frac{1}{2}$ sand or crushed stone.

Mortars for Dampproof Courses

(Slates in cement m.).

A fairly rich cement mortar should be used—not leaner than 1 cement to 3 sand. But it is a mistake to use neat cement, which tends to shrink, craze and crack.

RE-POINTING

This is the most common wall face repair. It is sometimes carelessly or ignorantly done, so that the pointing mortar soon drops out. The following method is reliable.

Rake out the joints to a depth of at least $\frac{3}{4}$ in. Thoroughly brush out all loose material with a stiff bristle or wire brush of suitable shape. Wet the wall twice in dry weather—a whitewash brush can be used to splash the water on from a bucket, or on large areas a hose may be used. The wall should not be soaked, but it must have more than a surface

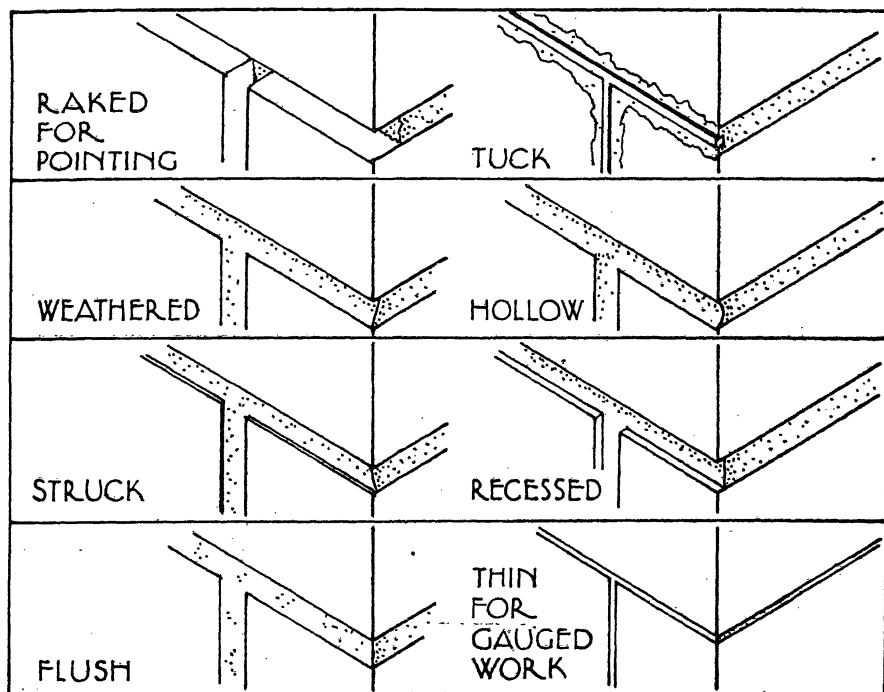


Fig. 29.—POINTING AND JOINTING

wetness. This is important as dry brickwork or stone will soak up the water out of the mortar so quickly that the mortar will not set properly, and will shrink. On a wall exposed to hot sun or a drying wind it is not easy to get the work in a properly wet condition. Protect the pointing from hot sun by covering with building paper. If this is impossible, work on a wall only when it is shaded.

Various pointing finishes are illustrated in Fig. 29.

Bricklaying in Frosty Weather

When there is risk of frost, the work should be covered with thick sacking or straw when it is left. In very severe frost work should be suspended.

Calcium chloride or sodium chloride (common salt) is sometimes used in a proportion of 7 per cent. of the weight of cement. The effect is to lower the freezing point of the wet mixture and to increase the rate of evolution of heat during setting, but the salts corrode steel reinforcement, and sometimes affect the strength of the work. Some slight risk is therefore involved, and they do not give protection against very severe frost. Altogether this practice is not recommended.

Work seriously damaged by frost should be pulled down. If the pointing only is damaged, the joints should be deeply raked and re-pointed.

SURFACE DECAY

The breaking up of brick and stone surfaces is frequently encountered. This may be due to material of poor quality which is unable to resist the ordinary range of atmospheric conditions. Another cause in material of low strength is the presence of salts in the brick, stone or mortar. These are the salts which cause efflorescence. They are soluble in water, and rainwater as it evaporates draws the salts to the surface. They may there be deposited as a white efflorescence, or they may set up pressure in the surface pores and so break up the material.

If these salts are present in considerable quantity they may exert sufficient pressure behind surface renderings to force the rendering away from the wall and break it-up.

Efflorescence

The cause of this white deposit has just been explained. Treatment is difficult. If the salts are washed off, further deposits will appear, but continual washing and scrubbing with ordinary water will eventually greatly reduce the trouble. There is no quick cure for a bad case.

The salts are sometimes introduced from the ground. An effective dampproof course will prevent the salts rising up the wall, but the trouble will appear below the d.p.c.

Portland cement contains salts which may cause efflorescence and break up the surface, and a rich cement mortar being almost impervious to moisture, causes the salts to be absorbed into the brick. As before stated, if a lime-cement mortar is used this trouble is not likely to occur.



Fig. 30.—AN OLD WALL BADLY IN NEED
OF TREATMENT
(George M. Callender & Co., Ltd.)

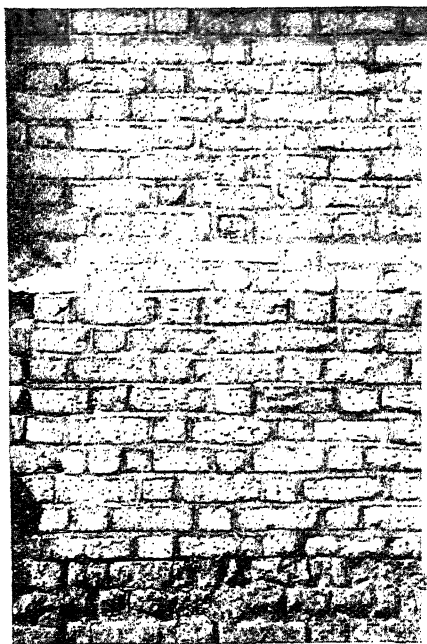


Fig. 31.—AFTER TREATMENT
(George M. Callender & Co., Ltd.)

Repairing Surfaces

Besides re-pointing, already described, the following methods are available:

Spot repairs.—Where the face is defective in patches. Cut out the defective bricks or stones to a depth of at least $2\frac{1}{4}$ in. and build in new material. Brush out all dust and loose material, and well wet the position before renewing.

Figs. 30 and 31 illustrate how an old wall was re-pointed, and treated with a liquid asbestic-bitumen compound.

Large areas.—These cannot be dealt with in the same way as spot repairs, as new work must be bonded in. This bonding may be done by cutting $4\frac{1}{2}$ in. deep for-snap headers, but the transverse bond obtained is, of course, not as good as full headers and the method is sound only for limited areas.

The whole wall.—With the whole wall surface badly decayed we have the choice of the following methods:

A new skin: A new brick skin may be built on to the face, after knocking or brushing away all loose material and washing down. This will increase the thickness of the wall. The new work should be bonded to the old with a course of headers to three courses of stretchers (three

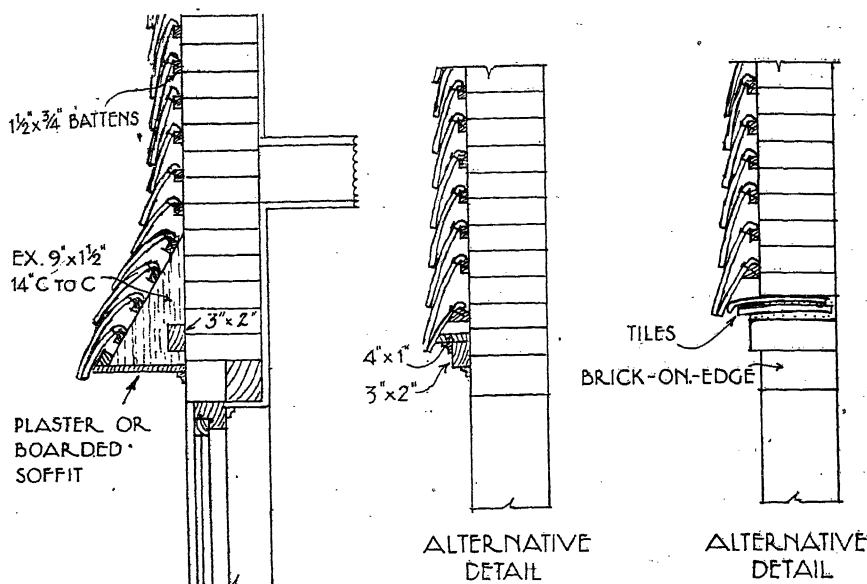


Fig. 32.—TILE HANGING

and one bond). Arches or lintels must be built over openings, and the jambs may present difficulties.

Rendering: If the surface decay is not too deep, the loose material may be brushed off and cement rendering applied. Suitable renderings are specified in Chapter VIII. This is perhaps the cheapest effective treatment, but renderings will not hold to crumbling wall faces, and it is essential to get rid of all loose crumbling material.

If the wall material is very poor stuff, or if there is much efflorescence, it is better to fix expanded metal lathing to steel rods stapled to the wall. This gives a good key and reinforces the rendering. Properly done it makes a first-class job even on a wall in very poor condition. It also dampproofs the wall.

Painting: Oil or other paints for wall treatment are effective on slightly decayed surfaces, provided no marked efflorescence is present. The surface must be thoroughly cleaned first. See Chapter XX. This is not a good treatment for a badly decayed wall.

Tile Hanging

This is a good protective treatment where it is desired to have a new burnt clay surface. Details are illustrated in Fig. 32. It can be used on brick, concrete or timber-boarded walls. It is better suited to the upper storeys of walls than the lower, as near the ground it is liable to damage. Tile hanging is used in both new and repair work to make a permanent dampproof wall. As it forms a cavity it adds considerably to the thermal insulation of the wall.

Nibbed tiles should be used, hung and nailed to wood battens secured to the wall. The battens should be treated with preservative and fixed to plugs. It is advisable to screw them to fibre or metal plugs. The battens should be $1\frac{1}{2}$ in. \times $\frac{3}{4}$ in. tiling battens spaced to suit the lap, and it is a convenience to have counter battens spaced at 18 in. centres. A lap of $1\frac{1}{2}$ in. giving a gauge of $4\frac{1}{2}$ in. with $10\frac{1}{2}$ in. tiles is suitable.

On timber-framed walls the tiles can be hung to battens nailed direct on the studs, but plain close boarding on the studs with the tiling battens nailed over makes a much better job, though the boards should be well soaked in preservative or covered with underfelt. The tiles can be hung to reversed feather-edge boards, and old boards can be taken off and reversed for this purpose, but the method is not to be recommended as the old boards are liable to rot.

Internal and external angle tiles are made for corners and jambs, and splay-cut tiles for verge finishes.

Slate hanging (nailing to battens) is illustrated in Fig. 33. As there are no nibs, corrosion of nails will cause the slates to drop.



Fig. 33.—SLATE HUNG ELEVATION, DEVON

STONE WALLS

The action of soluble salts on brickwork has already been described. Soluble salts also affect stone surfaces, but these salts are seldom present in the new stone—they are usually formed by the action of acids in a polluted atmosphere, though they can also be absorbed from mortar and other materials which are in contact with the stone, and from the ground.

The salts crystallise in the surface skin, and the pressure breaks up the surface stone in the form known as exfoliation.

Stone exposed to rain is not so badly affected as stone in a sheltered position. The rain washes the salts out of the surface almost as rapidly as they are formed.

Treatment

The Building Research Station recommend liberal washing periodically as the only sure preventive of decay from the above cause. Only clean water should be used—the practice of adding caustic soda or other chemicals, or even soap powder, is condemned.

For limestones it is recommended that the water be applied through a fine spray.

The use of proprietary stone preservatives is of doubtful value, and it is known that in some cases the solutions used have had a harmful effect.

Those based on colloidal silica appear to be the safest. The silica is a permanent binder and has no chemical action on the stone.

Oil paint and imitation stone paints are good treatments, though they change the appearance, and must be renewed at reasonable intervals.

Black grime cannot easily be removed by washing. Several firms specialise in steam cleaning, which effectively removes the black sooty deposit.

Repair of Stone

A badly decayed stone must be cut out and a new stone built in, using the mortar specified on page 44, or a similar mortar to that used in the old building, if this has proved satisfactory. The stone should be cut back to a depth of at least 4 in., and all soft loose material should be removed. Similar precautions should be taken regarding wetting and cleaning to those already described for brickwork.

The stone used in the repair should be the same as the original stone. Contact between stones of different types sometimes adversely affects one or the other.

A cheap method of renewing a badly worn surface is to cut away the loose and soft material and make up the surface with rendering (see Chapter VIII). The rendering can be ruled and blocked out to imitate joints. This is effective provided that the rendering is suitable and a good key is provided. Undercut holes should be made to form an effective key.

Cornices which are badly decayed can be repaired by the rendering method, but it is advisable to cover with expanded metal lathing wired to steel bars screwed to metal plugs.

Cornices with large projections may be cut back flush with the wall face if the building is of no architectural value. The flush face should be given a proper tooled finish.

Badly decayed coping stones should be removed, and it is better to replace with either pre-cast copings or poured concrete.

All stones should be so cut that they can be laid with the natural grain or strata horizontal, for the reasons stated in Chapter V.

COMPOSITE WALLS

In modern buildings stone is usually backed with brickwork. This is cheaper, and in some ways better than backing with stone. If the stone facing is thin, the soluble salts present in the brick backing may be drawn to the stone face by evaporating moisture and cause efflorescence. The back of the stone facing is sometimes treated with bitumen to prevent this trouble.

A modern method of applying stone facing is to use thin slabs of stone secured to the brick or concrete backing with metal cramps and dowels (instead of bonding). The method is occasionally used for re-facing a badly decayed or damp wall, the cramps being secured in the existing wall by cutting holes and grouting them in. As a repair method it is costly.

PRE-CAST STONE

This is essentially a concrete, though some cast stones incorporate crushed natural stone and coloured sands to imitate natural stone. The best cast stone, manufactured to the specification of the Cast Concrete Products Association, is by no means a cheap substitute for natural stone—it is often superior to the natural product.

The cheaper cast stones are sometimes finished with a surface slurry of cement and fine aggregate. This may conceal defects, and the surface skin is liable to craze. Trowelled cement skins often develop this trouble. The best finish for cast stone consists of removing the skin by tooling, grinding, or a special acid treatment.

There are so many firms making excellent cast stone and cast concrete products, that it no longer pays the builder to do it.

Concrete

The defects which may develop in concrete are due either to the use of unsuitable materials or errors in mixing and placing.

Aggregates must be clean. Soil and dust tend to weaken the concrete. Breeze and clinker may contain partly burnt coal which, in the presence of moisture, swells through chemical action. Breeze and lightweight concretes should therefore be protected from moisture.

Correct concrete practice is too big a subject to treat here, but a few important points may be mentioned.

Use only sufficient water to make a workable mix. Tamp carefully into position. See that shuttering is quite firm. Curing is important—this consists of retarding the drying by covering with building paper and watering through a rose occasionally.

Curing tends to prevent shrinkage, crazing, and cracking, and makes a stronger concrete.

Repairs to Concrete

Large cracks and fissures can be pointed or grouted after cleaning. With a deep narrow crack it may be advisable to chisel it to a greater width and undercut the section so that the mortar will be held. Such repairs are unsightly, and with extensive cracks it is better to render the wall after punching a key over the face. This keying operation is not always properly done. The punched holes should be fairly close and at least $\frac{1}{2}$ in. deep. A slight undercut should be given. All loose material must be brushed off and the surface well wetted before applying the rendering (see Chapter VIII).

Rendering is also the best cure for dampness due to excessive moisture in a porous concrete.

Efflorescence may be troublesome on concrete owing to the presence of soluble salts in the Portland cement. This matter has already been dealt with. As efflorescent salts may disrupt a rendering, it is advisable to use an expanded metal lathing on battens treated with preservative.

The grey appearance of a concrete wall surface is sometimes objected to. The surface may be limewashed, distempered, oil painted or treated with a cement paint. Distemper and oil paint may flake off if much efflorescence is present (see Chapter XX). A good proprietary cement paint is probably the best treatment at a reasonable cost. Tooling or grinding the surface usually improves the appearance, provided it is skilfully done.

TERRA-COTTA

The best materials are durable even in a smoke-polluted atmosphere, but like all wall surfaces, they are better and will last longer if periodically washed. Only clean water should be used. Caustic soda, soap powder, or any other chemical is harmful. If they must be used to remove grime, the surface should be thoroughly washed several times with clean water. Even so the chemical solution may penetrate joints and crazing and do harm. Steam cleaning is best for heavily grimed surfaces.

The defects found in terra-cotta are: Crazing of the glaze—usually not to a serious extent. Flaking of the surface may occur in a poor quality material due to the disruptive effect of soluble salts. Cracking and chipping occur through damage when fixing—often due to cutting the edge of a badly distorted block to make it fit in position. Terra-cotta should not be cut. Holes should be moulded in the material.

A lime-cement mortar is probably best for terra-cotta, and the mortar already specified is quite suitable for re-pointing.

Nothing satisfactory can be done to repair badly flaked terra-cotta (though this fault has almost disappeared in modern material). Blocks can be cut out and new ones made, or the face made good with mortar. New blocks should be filled with concrete, except where cornices project.

FACING SLABS

(Interior facing slabs and tiling is dealt with in Chapter VIII.) Exterior wall facings in slab form include marble, glass, slate, and metal

panels. The fixing of these materials is a specialists' job, and in repair work it is advisable to call in specialists (and often less costly). The repairer may properly make minor repairs where the methods of fixing are apparent and not difficult.

Heavy vibration, such as that produced in air raids, is usually the cause of the displacement of glass and other slab or tile facings.

BOARDED AND SHEETED WALLS

Weather boards, corrugated iron, asbestos-cement and other sheeting materials fixed to frame buildings are either fixed direct to a timber frame or to timber battens bolted to steel or reinforced concrete.

In repairs the timber frame or battens should be inspected and any decayed portions cut out. Preservative treatment of all timber is advisable, especially where damp may penetrate, or there is lack of ventilation.

Defective weather boarding should be thoroughly repaired—half measures merely waste money. Every board affected by rot should be removed. Warping admits rain and wind, but a warped board may be re-nailed, if otherwise sound. Extensive rot, usually involves the timber frame or battens. All unsound timber should be removed. Further information on timber rot is given in Chapter XII.

Weather boarding should have underfelting to stop wind and rain driving through the laps. The strength and insulation of the wall is greatly improved by under-boarding, especially if this is nailed diagonally across the framing.

Asbestos-Cement

This cement does not deteriorate, but hardens with time. It does not require painting, but defects may occur through mechanical damage, faulty fixing, or the corrosion of unprotected bolts and drive screws.

Years ago, cheap asbestos-cement sheets were on the market, made by an inferior process. This material is weak, and sometimes breaks up or crumbles. But the reputable makes are amongst the most durable of materials.

The fixings of the sheets may need attention. Asbestos-cement must have a certain amount of free play to allow for expansion and contraction of the supporting frame. Bolts and drive screws should be placed on each side of the side laps—not through the lap. Double washers of felt and lead should be used, and the fixing should not be very tight. The hole should be slightly larger than the bolt or screw.

Small defects due to mechanical damage can be patched with cement mortar or mastic, but it is advisable to renew damaged sheets.

Special corner pieces and other fittings are made for use with asbestos-cement sheeted walls. In some cases these are not fitted, and the wall may admit damp or draught in consequence.

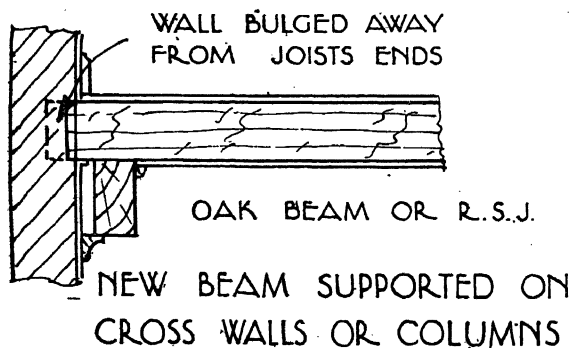
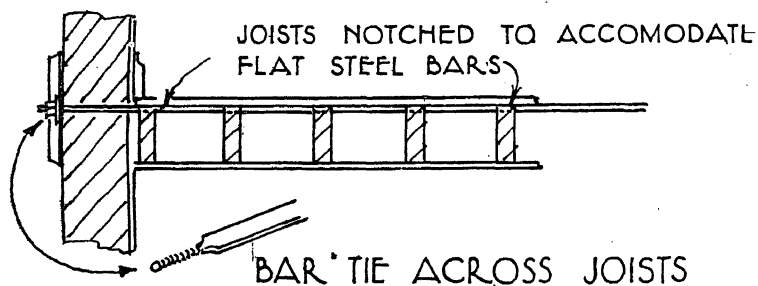
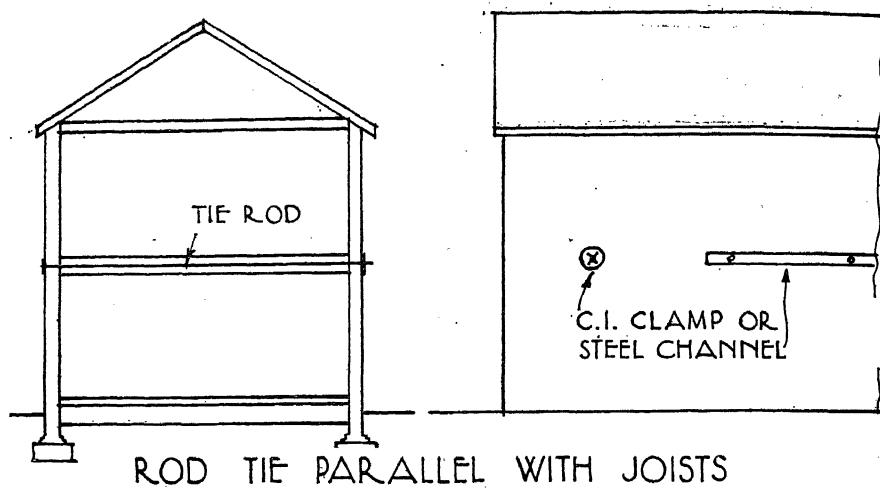


Fig. 34.—STRENGTHENING BULGING WALLS

Corrugated Iron

Corrosion is the enemy of this material. If the galvanising is damaged, corrosion will spread and gradually lift the adjacent galvanised surface. Slight spot corrosion may be cured by thoroughly cleaning with emery cloth, and painting (see Chapter XX). Badly corroded sheets should be renewed.

Protected Metal

This type of corrugated sheeting is now much used. The steel core is sealed in a bituminous composition. Faults are not likely to develop provided the bituminous outer skin is not penetrated.

Any damage to the outer skin could be repaired by treating with a bituminous paint or mastic.

Strengthening Walls

Permanent strengthening (timber shoring is a temporary measure) consists of the addition of piers, buttresses and steel cross ties.

Settlement, cracking and bulging can be arrested by building piers or buttresses at intervals of from about 6 to 12 ft., taking care to properly bond the new work to the old.

Steel tie rods are often used to arrest bulging. Tie rods counteract the tendency of a weak or damaged wall to bulge outwards, and also counteract any outward thrust from untied rafters and vaults or arches. The tie rods should be fixed, if possible, in or near a floor and parallel with the floor joists, as shown at the top of Fig. 34. The tie rods pull the wall inwards and the floor joists resist this pull. If the rods are fixed at right angles to the joists the inward pull is not resisted, and care should be taken not to overtighten the rods.

Tie rods have a screw thread at each end, and are secured by nuts and washers over cast-iron plates or a continuous wall plate. The wall plate should be of rolled steel channel section.

When a wall bulges outwards it may leave the ends of floor joists with insufficient bearing for safety. A beam should be added inside the building, as shown at the bottom of Fig. 34, to support the joists, the beam ends resting on cross walls, columns or piers.

Chapter VII

DAMP PENETRATION AND CONDENSATION

DAMPNESS in a building chiefly affects walls and wall linings, floors and floor coverings, ceilings, structural timber, and decorations. Dampness may appear some distance from the fault or points of penetration. It is, of course, of great importance to trace the source before attempting a cure. Many treatment failures are due to the repairer treating some perfectly sound part of the building, the actual source of the trouble having eluded him.

CAUSES

The following are the chief sources of dampness:—

- (1) Direct penetration through walls.
- (2) Damp rising from the ground—up walls or through floors.
- (3) Damp soaking downwards from roofs, parapet walls, chimneys, etc.
- (4) Penetration between frames and walls, and through defective flashings.
- (5) Penetration through absorbent projections—cornices, mouldings, canopies, etc.
- (6) Condensation of atmospheric moisture on cold, impervious materials.

The last item, condensation, differs from the others as it does not involve any penetration of damp from without.

Drying Out

When a new building is drying out, the moisture is often mistaken for dampness due to defects. Actually, the dampness is caused by moisture contained in the walls, plaster, etc., being drawn to the surface by the normal process of evaporation. The extent of the dampness and time taken for complete drying out depends upon weather conditions during both the building period and the drying out period. Walls built in wet weather absorb a lot of water, and if the weather continues wet after completion the drying-out process can hardly begin.

Drying out can be accelerated by heating the rooms and leaving the windows open.

WALLS

Brick, stone, mortar, and concrete are absorbent, and though the rate of water absorbence varies with the density of the material, all such walls soak up a certain amount of rainwater. This does not matter if

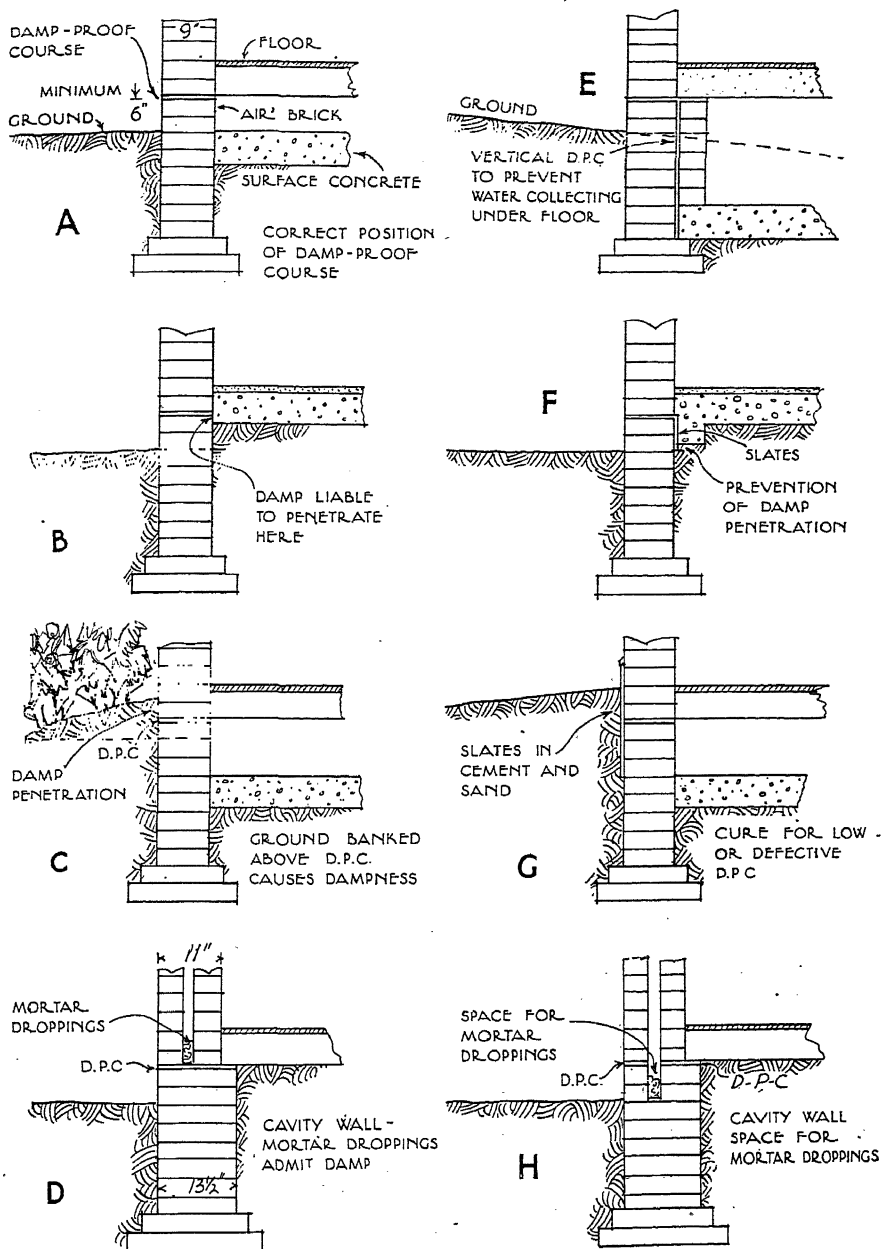


Fig. 35.—DAMP-PROOF COURSES

periods of dry weather allow the absorbed moisture to be drawn out by evaporation before it can soak right through the wall to the interior face.

In an exceptionally exposed position, or during an exceptionally prolonged wet spell, damp penetrates almost any solid wall of normal absorbent material. Experience shows that if the position is reasonably sheltered ordinary 9 in. or 13½ in. solid brickwork does not admit damp. If the position is exceptionally exposed a dampproof wall system should be adopted—cavity walls, as described in Chapter V, or rendered walls, as described in Chapter VIII.

Deep Projections

Deep eaves and cornices help to shelter walls, provided they are waterproof. Most old buildings are better than modern ones in this respect. Many modern buildings have flat roofs with parapet walls and no eaves or other projections.

Dampproof Courses

There should be an impervious (dampproof) course in every wall between the ground and the ground floor. This should be at least 6 in. above ground level (as in Fig. 35A and B). In many buildings it is lower and damp rises above the d.p.c. owing to rain splashing up from the ground, or to the soil being dug and raised, as in Fig. 35c. The cure for this trouble is to lower the ground level.

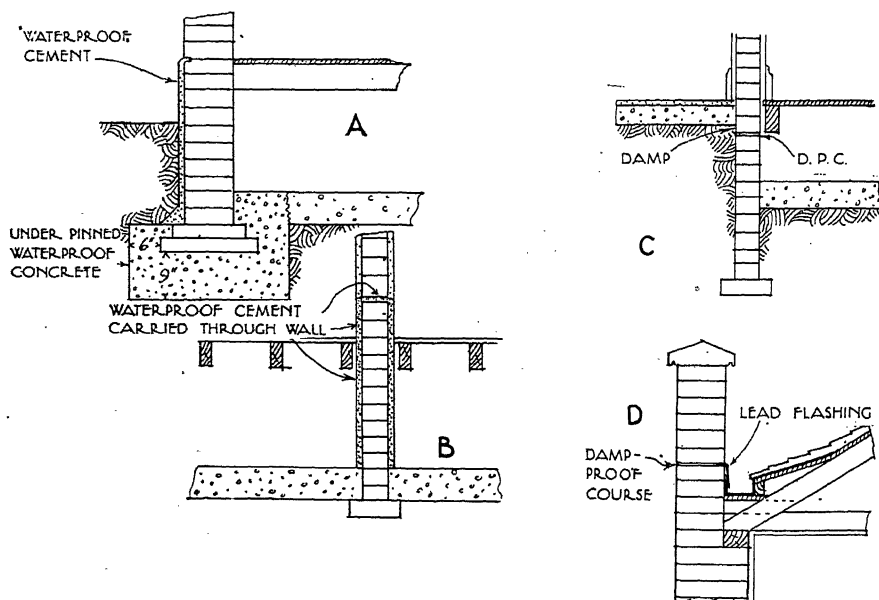


Fig. 36.—DAMPPROOF COURSES

The effect of terminating the cavity (in a cavity wall) is shown in Fig. 35D. Mortar collects on the d.p.c. and moisture creeps across.

Where the ground is very damp, moisture may penetrate solid (concrete) ground floors. In new work a horizontal d.p.c. should be placed in the floor concrete. This d.p.c. may be bituminous felt, asphalt, or waterproofed cement.

In some old buildings there may be no dampproof courses, and walls and floors may be damp from this cause. A d.p.c. of two courses slates in cement should be inserted in the old walls in short lengths—cutting out a few bricks or stones at a time.

If the walls are badly decayed, the d.p.c. may consist of waterproofed mortar (using a proprietary waterproofer strictly to the maker's instructions) and the same mortar may be used as an external or internal rendering between this d.p.c. and the ground or foundations, as shown in Fig. 36A and 36B. This waterproofs and preserves the lower part of the walls.

Fig. 36C illustrates a point at which damp sometimes rises up an internal wall when a solid floor is one side and a wood floor the other, and the d.p.c. is too low. The remedy is to cut into the solid floor and set slates in cement as a vertical d.p.c. against the wall face.

Parapet Walls

These should have a d.p.c., as well as a coping of dense material. Most old parapets lack a d.p.c., and water soaks down the wall and appears on plaster and ceilings. The remedy is to remove the coping and top courses, and insert a d.p.c., as shown in Fig. 36D, in such a position that water cannot soak down below roof surface level.

Parapet walls, having no deep projection to shelter the wall below, allow rainwater to seep down the wall face and soak through—especially if the parapet is very high. This trouble may be cured by inserting a lead or copper d.p.c. and projecting it over a hardwood moulding (teak is best for this job).

Badly decayed parapets should be rendered with waterproofed material. This material may be used to bed a new coping, and so form a d.p.c.

Cracks in Walls

May be due to unequal settlement, decay, or bulging. It is important to discover and remedy the cause or the cracks will extend and new ones appear. Defective foundations may cause unequal settlement, leaning and bulging. This may cause zig-zag cracking along the joints, or in bad cases the bricks may crack through. Provided the wall is not in a dangerous condition, it is sufficient to strengthen the foundations, as described in Chapter VI, and then fill the cracks and fissures with lime-cement mortar. If in an exposed position, a waterproofed cement mortar may be advisable. The mortar should be forced in to completely fill the depth of the crack. Grouting (with a semi-liquid mortar) may

be necessary in some cases, removing a brick or stone here and there to enable the grout to be poured in.

Mortars and Joints

Dampness is sometimes caused by a defective or unsuitable mortar. An excessively absorbent mortar, such as a poor quality lime mortar, or a mortar affected by frost, may admit damp. But in modern buildings the trouble is sometimes due to the use of a rich cement mortar. As previously stated, a rich cement mortar tends to shrink and open fine gaps between the mortar and brick or stone. These very fine cracks may be almost invisible, but they admit moisture by capillary action (water will not only pass through a horizontal crack or gap by this action, but will also rise vertically, as may be seen by placing the lower end of a thin glass tube in water—the water slowly rising in the tube).

As stated in Chapter VI, a lime-cement mortar does not shrink much, and adheres better than a cement mortar. The lime-cement mortar mix specified on page 44 is certainly better for damp resistance. If the mortar joints are suspected as the cause of dampness, the lime-cement mortar specified should be used for re-pointing, taking care to rake out and damp the joints, as described in Chapter VI.

Cornices

Cornices, string courses and other wall projections may cause dampness by catching rainwater as it seeps down the wall so that the wall just above the cornice becomes saturated. The cornice or string course may itself be absorbent—joints and cement fillets may be defective. Re-pointing and renewing cement fillets may cure this trouble, though, in some cases, it may be necessary to fix a lead or copper flashing over the projection, turning it up the wall into a wall joint.

Projecting tile creasing (one or more courses of roofing tiles bedded in the wall) should be protected by a cement fillet weathered (sloping outwards) on the top, but these fillets sometimes crack or craze, and need renewal. A metal flashing is better.

FRAMES AND OPENINGS

A frequent cause of dampness is the opening of a gap between a door or window frame and the jamb of the wall opening. Shrinkage of a wood frame is usually responsible. Cement mortar for pointing is satisfactory as long as no further shrinkage of the frame occurs. There are several proprietary bituminous mastics for pointing these gaps. They retain a certain amount of elasticity for some years. Fig. 37 illustrates these gaps and the operation of pointing.

Steel window frames should be pointed with the special mastic supplied by the makers, but any bituminous pointing is good for repair work.

If wood frames have rotted, re-pointing the gaps will only effect a

temporary cure for dampness—the rot will probably be accelerated by the pointing.

Sills

Rainwater collects on flat sills and will soak through any cracks or porous material. The gap between wood sills and wall should be pointed with mastic, tamping it well in with an old wide-blade wood chisel, and the brick or stone sill re-pointed with cement mortar. If the sill is badly decayed it may be rendered, or covered with lead or copper—though ground floor sills may be maliciously damaged on some buildings. Cutting out the old brick or stone sill and renewing with dense material (preferably pre-cast concrete sills) is the best if most costly cure.



Fig. 37.—WHEN THE JOINT BETWEEN THE WINDOW FRAME AND THE BRICKWORK IS SO HOLLOW THAT THE POINTING MORTAR WILL NOT HOLD, STUFF WITH PAPER AND THEN POINT UP (Photo: L. E. Walker)

Arches and Heads

The general decay and settlement of an arch causes the wall to crack and admit damp. Even slight settlement will do this. The cracks can be closed by pointing, but steps must be taken to arrest the settlement or other movement. Badly decayed faces of arches may be rendered and painted. This cures dampness and preserves the work.

The deflection of lintels is sometimes so great that the walling above settles and cracks. This is not usually dangerous, but it admits damp. In most cases the dampness can be cured by carefully pointing the cracks, but this repair looks rather unsightly. Short of removing the lintel and replacing with a stronger one, nothing better can be done.

The voussiors of arches may in some cases be wedged or jacked up from a firm staging, and so restored to their original position, but great care is needed or further damage may be done. The arch should afterwards be thoroughly pointed.

Flashings

Defective flashings to window heads, under sills, cornices, string courses, chimneys, roofs, etc., may admit damp. In some cases the

trouble can be cured by re-pointing. In others the trouble is due to decay of, or damage to, the flashing, which requires renewal.

Flashings are further dealt with in this book in connection with the parts of the structure to which they give protection.

Lead, copper, zinc, and asphalt are the best flashings. Bituminous felt is sometimes used—particularly as a flashing between flat felted roofs and parapet walls. The felt is not very good for this purpose as it sometimes cracks or is otherwise damaged when bent. It is difficult to seal the flashings with mastic, and if this is not efficiently done the wind may disturb it.

Cavity Walls

Good practice is described in Chapter V. Any faults tend to admit damp. The chief faults are:

Mortar droppings on ties.—Difficult to cure as access must be gained by opening the brickwork. If damp appears in one or two spots, these areas may be opened and the ties cleared. If it is general, open the end of the wall so that a long lath may be used to push the mortar off the ties, starting at the top and working downwards. This is only permissible if there is a space below the d.p.c. at the foot of the cavity.

Incorrect position of d.p.c. and cavity bottom—the cavity should extend at least two courses below the d.p.c., so that the d.p.c. should be in two separate portions. Mortar droppings are then accommodated at the bottom of the cavity below d.p.c. level. If cavity terminates at d.p.c. level the mortar droppings form a porous bridge by which moisture can pass from outer to inner leaf, as in Fig. 34D. This trouble may be cured in short walls by opening the ends of the wall and raking out the droppings with a long lath having a hoe-shaped piece of metal attached to the end, but water may still creep across the one-piece d.p.c.

Parapets without d.p.c.s.—This results in damp penetration from rainwater soaking down the parapet wall. In some cases the d.p.c. is so placed that water can pass from the outer to the inner leaf. The parapet wall should be taken down and a d.p.c. placed in a correct position.

Flashings over door and window openings.—These should extend through the outer leaf and be taken up the back of the cavity and turned into a bed of the inner leaf, as shown in Fig. 28. If this detail is faulty damp will penetrate. The flashing should extend laterally for 6 in. beyond each end of the frame so that water collecting on the flashing will fall clear into the cavity.

Attempts are sometimes made to cure faulty cavity walls by making small openings at the top and bottom of the outer leaf with the object of ventilating the cavity, as in Fig. 28. This rarely achieves a cure for dampness, and the ventilation reduces the thermal insulation of the wall.

SURFACE TREATMENT

For walls which are excessively porous and admit damp all over or in large areas, various brush-applied treatments are available, and also the more costly treatments of rendering and tile or slate hanging.

Brush-applied treatments have been classified as follows:—

Slurries or washes of lime or Portland cement. External distempers; oil emulsion types. Bitumen emulsions: (a) black, (b) coloured. Normal oil paints. Special alkali-resistant paints, often containing coarse fillers, which give a stone texture. Inorganic washes of silicates.

These treatments cover the wall with a waterproof film, but they all require renewal at intervals of from one to five years.

Lime Washes

Washes and slurries have been used for hundreds of years on cottage walls, and the Building Research Station commend this treatment, using the following mix:—

5 lb. tallow is stirred in with water to 1 bushel (eight gallons) of quicklime to make a paste of creamy consistency which may be applied with a brush. The quicklime is slaked in the ordinary way and, while hot, the tallow is stirred in. Linseed oil may be used instead of tallow. An insoluble calcium soak results which has useful binding properties. Pigments can be added if desired. This treatment will require renewal every year, so it is not suitable for large buildings.

Cement Slurry

This is sometimes used to waterproof walls. It is useful in filling open pores and cracks, but is liable to craze, and is itself absorbent. A mix of two parts lime to one of cement tends to prevent crazing. A very rich cement slurry may craze and flake off.

External Distempers

There are oil emulsions with pigments added. They give better and more durable results than lime wash or slurry. The makers supply a special liquid for thinning, and water should not be used. Good adhesion is not always achieved, and flaking is a common fault, though if the loose distemper is cleaned off, a second treatment is usually successful. In any case the treatment must be renewed every few years.

Bitumen Emulsions

Black or coloured, these are effective for about five years, if of suitable type. The most reputable brands give very good results—but the cheaper brands are often unreliable. These emulsions do not hermetically seal the pores of the wall, so the wall can dry out and “breathe” after treatment. Weather resistance is excellent, but neither the black nor colours look attractive.

Oil Paints

Oil paints suitable for external use have long been used for damp-proofing external walls, and are very good if a renewal coat is applied every few years. The first cost is rather high. A dry and chemically stable wall surface is essential. Excessive moisture in the wall tends to force the paint off. Alkalies, such as are present in Portland cement and in some brick clays, will in the presence of moisture, attack oil paint, but special primers are made which reduce this risk. Special alkali-resistant paints are produced for masonry.

Silicate Paints

These are resistant to alkalies, and can be safely applied to new Portland cement and new brickwork. They are not absolutely water-proof, but give greatly increased resistance to damp.

Proprietary Waterproofers

These are widely used, and applied with a brush. They require no special skill in preparation or application, but it is necessary to comply with the maker's instructions. Most of these waterproofers are transparent, though the appearance of the wall is altered. The tint is darkened, and a slight gloss results. The walls must be clean and dry when the treatment is applied, and the treatment must be renewed at intervals of about 4 years. Two coats are usually necessary.

Waterglass

(Silicate of soda). This may be used as a transparent waterproofer. The wall must be clean and dry. Apply two coats and renew every three or four years. The grade known in the trade as P. 84 should be used.

CONDENSATION

Condensation of atmospheric moisture tends to occur on cold non-absorbent surfaces. Such surfaces quickly lower the temperature of the air, and as the capacity of the air to hold moisture decreases as the temperature is lowered, moisture forms on the cold surfaces.

It follows that material having good thermal insulation, retaining warmth for a long time while the atmospheric temperature is falling, discourages condensation. To give familiar examples: condensation readily occurs on glazed tiles and window glass, but not on a thick wall or fibre board.

The density of the material also influences condensation. A moderate amount of condensed moisture can be absorbed by a porous material, but such moisture will collect in drops on a non-absorbent surface. Such condensation is often called sweating.

The movement of the air tends to prevent condensation by removing the moist air before the moisture can condense. Good ventilation

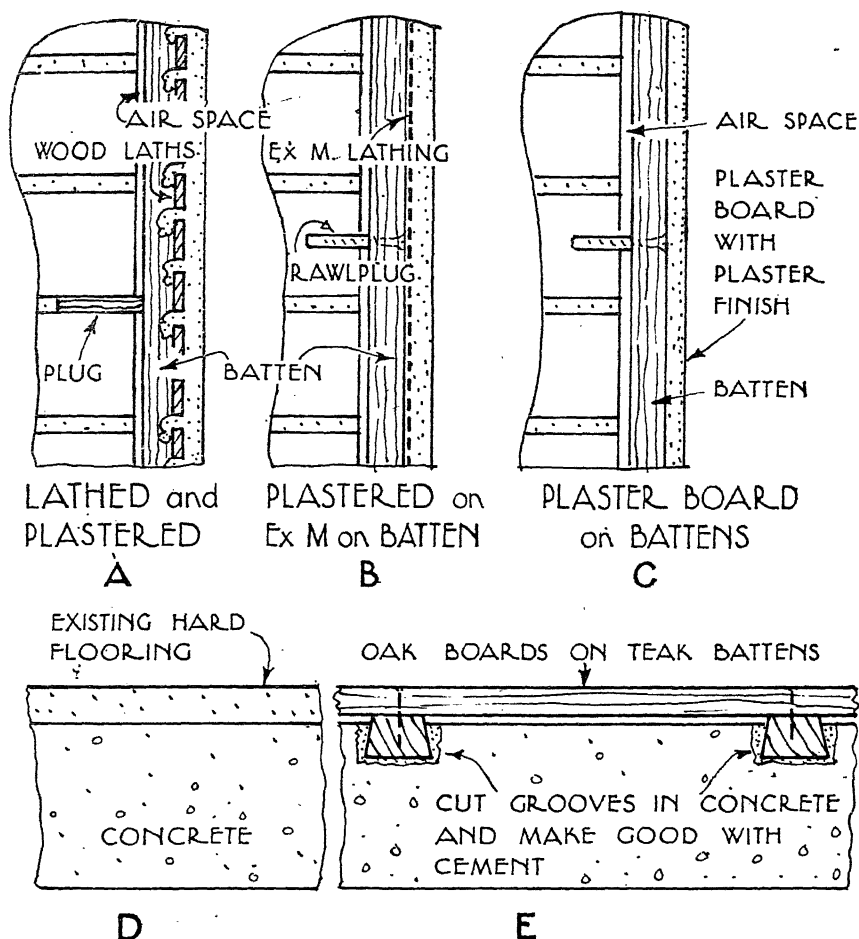


Fig. 38.—CURING CONDENSATION

therefore tends to reduce condensation, though under bad conditions it may not cure it.

Curing Condensation

The materials used should have low thermal conductivity and hence high thermal insulation, and an absorbent surface to absorb a moderate amount of condensed moisture. Good ventilation and heating also assists in preventing condensation.

Hard, non-absorbent plasters may be hacked and finished with a moderately absorbent plaster, or painted with an insulating paint, such as "Cork-Tex."

The thermal insulation of walls can be improved by wall plastering on lathing on vertical battens; the air space behind the laths and the extra thickness of material providing considerable extra insulation, as in Fig. 38A. This method is used in Scotland. The Building Research Station suggest an alternative, illustrated in Fig. 38B. The inside of the wall is battened on plugs, using Western red cedar (which is rot-proof) or treating other wood with a colourless non-bleeding preservative, and expanded metal lathing backed by hessian stretched tightly over the battens is used to provide a key. The hessian is necessary to prevent plaster filling the cavity. Another suggestion is that fibre board or plaster board should be fixed to the battens as a substitute for the plaster undercoat, as shown in Fig. 38C.

Condensation on tiled, granolithic, and other hard floor surfaces, having a concrete base, is not easy to cure by structural treatment. In a new building it can be prevented by providing an insulating layer under the floor—such as a layer of hollow clay blocks on concrete with a concrete screed on top.

Where condensation occurs on an existing hard floor, as in Fig. 38D, attention should be given to ventilation and heating. If that fails, the hard flooring might be removed and an oak or teak boarded flooring put down, cutting grooves in the concrete to take teak or western red cedar battens, as shown in Fig. 38E. Such treatment is costly, and it is well worth first trying the effect of improved ventilation and heating.

The steam generated in kitchens is often a source of condensation. An asbestos-cement hood should be fitted over cookers, boilers, etc., with a pipe carried through the wall and fitted with a cowl, to carry away the steam.

Chapter VIII

PLASTERING AND RENDERING

THERE is no part of a building so likely to develop defects as the plastering. Attempted cures are often unsuccessful owing to the wrong treatment being adopted.

There are five chief causes of failure:—

- (1) Faulty material such as imperfectly slaked lime, and poor quality wall material.
- (2) Faulty methods, such as applying second or third coat before the undercoat is dry.
- (3) Shrinkage after completion, often due to fault 2.
- (4) Movement of the supporting structure, such as shrinkage of joists and studs, wall settlement, and movement of laths owing to improper lathing methods.
- (5) Efflorescence or crystallisation of soluble salts on the interface between wall and plaster back, resulting in plaster or rendering being forced off the wall.

LIME PLASTER

Before further describing faults and cures, it will be useful to define good lime plaster and plastering practice. The plaster consists of slaked or hydrated lime. Hair is added to the undercoat to help bind it while it sets.

Internal Wall Plastering

Should be three coat work, consisting of rendering coat, floating coat, setting coat. In cheap work two coat plastering is sometimes adopted. This is more likely to develop defects, and is difficult to bring to a true surface.

Undercoatings (coarse stuff) should consist of 1 part lime to 3 parts clean sharp sand (by measure). Add 1 lb. of hair to every 3 cubic ft. of coarse stuff.

Setting coats (fine stuff) should consist of 1 part plasterer's putty to 2 parts fine sand (by measure). For rapid setting gauge coarse or fine stuff with plaster of Paris:—1 part plaster of Paris to 3 parts coarse or fine stuff, though proportions vary.

The first coat of haired coarse stuff should be about $\frac{1}{2}$ in. thick. This is usually called pricking up. The surface should be scratched while still soft to provide a key.

The second coat should be $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick. Apply when the first coat is dry, and screed to bring to a plane surface. Screeds are narrow

strips of plaster plumbed and levelled. In cheap work wood laths are sometimes used, and afterwards removed and the gaps made good with plaster, but this may form lines of weakness.

The third or floating coat is then applied and levelled off with the floating rule by passing it over the screeds. This third coat should be about $\frac{1}{8}$ in. thick.

Ceiling Plastering

This is the same as for walls, with the addition of lathing. Plasticity is of importance, and should be just sufficient to work the plaster between the laths to form a good key. The plaster, in fact, should hang on the laths.

Lathing

Wood laths should butt on the joists or studs and should break joint. As timbers are not often regularly spaced, it may be necessary to cut a special length of lath to bring the end to the middle of the joist or stud. Butt joints should not be made in a line (along one timber) but should break joint.

The space between laths should be $\frac{3}{8}$ in., and should vary from this by less than 1-18th in.

Drying

Drying of the undercoats is most important. The first coat should be dry and fully shrunk before the second is applied. The setting coat can usually be applied two days after the second coat.

Slaking Lime

The slaking of lime calls for considerable skill and experience. Many faults arise from imperfectly slaked lime. Use a reputable make, the lumps of which are properly burnt—partly burnt lumps will not slake properly, and if detected during slaking should be removed. This can be done by first placing the lime in a tub of water, breaking it up and mixing it. Then take it out and pass it through a fine sieve into the sand basin. The stuff that remains on the sieve should be discarded.

A rich lime tends to slake rapidly and generate excessive heat. Sufficient water must be added to prevent the lime burning. Burning is weakening. The use of too much water will also weaken the lime. Experience alone is the guide, especially as limes from different makers vary in this respect.

The maturing of slaked lime is important. It used to be left for three years—nowadays the period is sometimes less than three months—and the pitting and blowing of plastered surfaces is usually due to insufficient maturing.

It is a good plan to keep a stock of slaked lime in bins, and to add to it

from time to time. Repair work can then be undertaken with properly slaked and matured lime.

Plasterer's putty is fine thoroughly slaked lime, prepared in a tub, as previously described, and passed through a sieve.

Hydrated Lime

Ordinary lime, properly slaked and matured for at least twelve months, cannot be bettered, but use a proprietary brand of hydrated lime rather than insufficiently matured lime.

Two qualities of hydrated lime are marketed. Grey hydrated lime for coarse stuff, and white hydrated lime for fine stuff. Hydrated lime is ordinary lime slaked at the works, dried and powdered. On the job it should be mixed with water and left for forty-eight hours. It is then ready for use.

Quick and Hard-setting Plasters

Plaster of Paris, Portland cement, sirapite, selenitic lime, Keen's cement, Martin's cement, and parian cement, give a hard dense plaster, and are quick setting. They are widely used, especially for setting coats.

These plasters are very useful for repair work, as they can be conveniently prepared in small or large quantities. Use strictly to the maker's instructions.

Hard plasters should be used for external angles. Wood staves are bad—the plaster fails to adhere to them. But metal trim angles can be used.

A hard plaster surface unfortunately encourages condensation (see Chapter VII), and in some buildings is the cause of troublesome echoes. Both troubles may be prevented in some cases by using a wood float and leaving a slightly rough surface, instead of the smooth polished surface left by the steel trowel.

FAULTS AND REMEDIES

The cause of many faults will be understood from a study of the above-described principles of good practice.

Pitting and Blowing

Both are due to imperfect slaking of the lime—which in turn may be due to the lump lime containing unburnt pieces, or to over burning due to overheating in the slaking treatment. Cut out the faulty spots, forming an undercut, and make good with any of the previously mentioned plasters.

Crazing and Cracks

Imperfect slaking of lime, faulty lathing, shrinkage or settlement of walls and timbers, imperfect drying-out of undercoats before setting coat

was applied may result in crazing and cracks. Very fine crazing may be covered with a coat of limewash or distemper, but cracks must be repaired. To do this make an undercut just wide enough to allow new plaster to be forced in. The undercut section will make a good key. It is useless to fill cracks without this treatment, as the new material will probably crack away from the old.

If the cause of the cracking is likely to continue the trouble (as with wall decay or rot in joists) this must be remedied.

Cracking often occurs at the junction of ceilings and walls. A common fault occurs where a wall plate is set flush with the inside wall face. This does not provide a key, even if a lath is nailed to it. The cure is to fix a strip of expanded metal lathing on the plate to provide a key. This should be stapled to short pieces of vertical counterlath so that the plaster can pass through the expanded metal and hang to it.

Another cause of cracking is where the wall plate is below the ceiling on the outer half of the wall. If the inner brickwork is not continued above the ceiling, and plaster is merely pressed on top of the wall, it will crack. In repairing, set brick bats in mortar, or fix wood blocks on which expanded metal should be stapled to form a firm key.

At any point where the cause of cracking is due to lack of a good key, expanded metal lathing may be used in the repair.

Where the means of support for the lathing is very widely spaced, a ribbed expanded fabric can be used. There are several proprietary makes.

Cracking due to lathing faults is common. Laths may be placed too close together. Ends may run over joists and studs. The butts may be lined up along one joist or stud instead of breaking joint. Where these faults exist extensively the plaster may not only crack, but the adherence generally may deteriorate, so that the plaster "bellies"—sagging in patches, until it falls. If the plaster is firm the cracks may be repaired by forming an undercut, as already described. If it is failing generally it must be stripped, and the lathing defects put right before replastering.

If timbers are more than 2 in. wide, nail battens to them before fixing laths. Otherwise the plaster cannot be properly keyed over the wide timber.

Falling Plaster

This may result from any of the faults previously described. It is often due to lack of proper drying out of the undercoats, to poor key on the undercoats (through these coats not being scratched sufficiently), and to lathing defects. Sagging of weak joists and warping of studs may cause the failure. If due to the latter cause, the supporting timber must be strengthened and relathed before replastering. Alternatively, a fibre or plaster board may be used as a new facing.

WALL AND CEILING BOARDS

These boards are useful as wall and ceiling linings where the structure is not suitable for replastering. They can also be used for extensions, and for partitions, where the job must be quickly done. The thicker boards are used where sound and thermal insulation is required, and it is well to point out that thin hard wallboard is useless for sound insulation.

The boards are of various materials. Fibre boards consist of compressed fibres—some being fire resistant by reason of the asbestos fibre used. The ordinary fibre boards absorb moisture, but a non-absorbent type is made (though not suitable for outside use). Plaster board is another type. This is simply hard plaster in sheets, and may be obtained with a smooth finished face, or a rough face to which a finishing coat is applied after fixing.

Most boards must be nailed at 16 in. centres, so that joists, studs, or

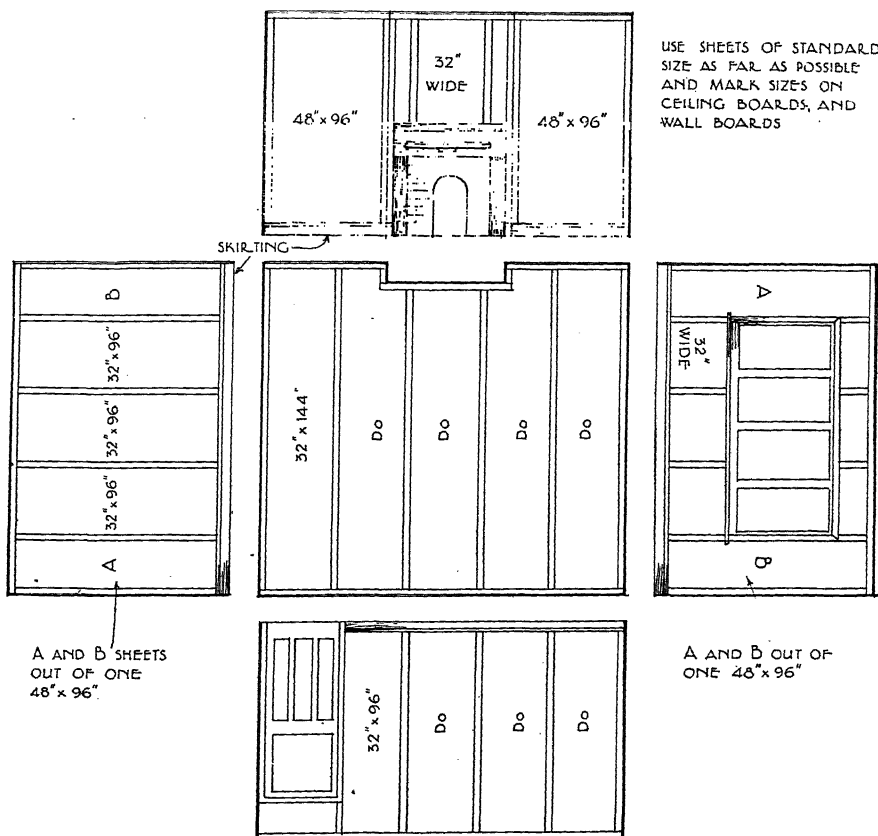


Fig. 39.—LAYOUT OF FIBRE BOARD

battens must be fixed at these centres. Spreaders or cross battens must be fixed to take the short edges of sheets. Sheets can be fixed vertically or horizontally. Fig. 39 shows how to lay out the boarding.

The chief features of fixing are illustrated in Fig. 40. The instructions issued by the makers should be followed in fixing, but the following is

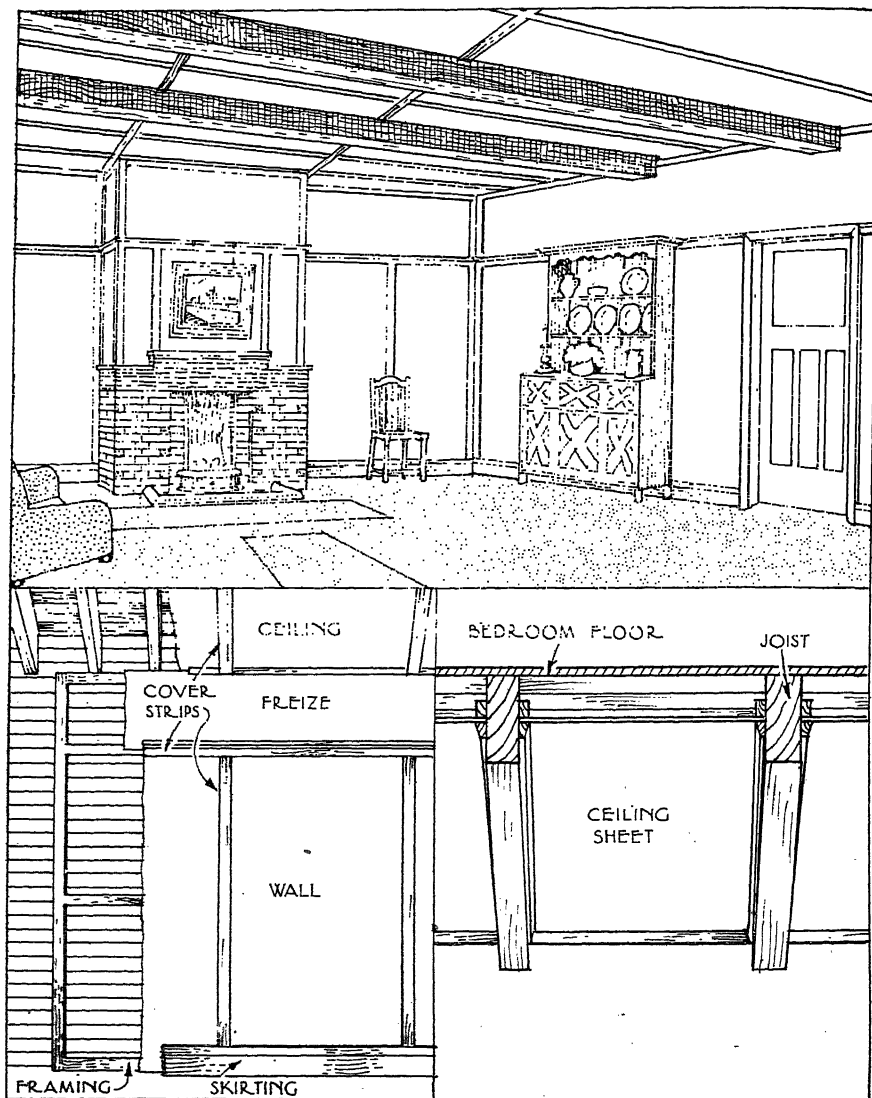


Fig. 40.—SCHEME FOR REPLACING PLASTER WITH FIBRE BOARD

common practice:—Use 1 in. round wire nails spaced at 6 in. intervals along the edges and 9 in. along the intermediate supports.

The boards may be jointed by using wood cover strips or an embossed paper strip; or, if a flush surface is desired, linen strip should be pasted over the butt joint. The boards are usually sized ready for treatment with distemper or oil paint—though in the latter case a priming of boiled oil and turpentine is advisable.

For kitchens and bathrooms there are glazed and decorated asbestos-cement flat sheets, which are non-absorbent, and not affected by damp, though condensation may occur on the surface.

Plywood sheets and highly compressed reconstructed wood sheets (usually called hardboard) are also useful in providing new linings to old walls and ceilings, and in extensions.

There are many proprietary wall and ceiling boards, and the interested reader should obtain catalogues from a builders' merchant, and study the various types.

There are several patent systems of fixing, using pressed metal bars and clips.

EXTERNAL RENDERING

This method of plastering the exterior of a wall is often used in repairs. It will make the wall dampproof, and protect the walling materials from further decay.

Unfortunately, failures of rendering are common. These include crazing, cracking, and falling off in patches.

Faults

These faults are often due to the use of a too rich cement mix. Other causes are: Efflorescence on the interface of wall and rendering forcing the rendering off the wall, and defective walling material. Wall settlement will, of course, crack the rendering.

Cracks which remain stationary may be repaired by undercutting and making good.

Rendering Mixes

A lime-cement-sand mix, as recommended by the Building Research Station, is a safe guide. The mixes are:—

Undercoat (parts by volume): 3 parts white hydrated lime or stiff lime putty, 1 part Portland cement, 10 parts clean sand or crushed stone aggregate. Finishing coat: 3 parts lime as above, 1 part Portland cement, 12 parts sand or crushed stone according to colour and texture required.

If lime putty is used, this may be knocked up into lime-sand coarse stuff, and the cement added before use. All material should be used up within two hours of the cement being added.

If the wall is exposed to driving rain a cement-sand mix is better for the undercoat. Mixes vary: 1 part Portland cement to 4 parts sand is suitable, and in a very exposed position a good proprietary waterproof may be added to the undercoat. The mixes recommended by the makers should be adopted.

There is great variation of practice in renderings, but it is clear that a lime-cement-sand mix is not likely to develop crazing and cracking, whereas a rich cement-sand mix is.

Rendering Old Walls

If the walling materials are badly decayed, this may not be successful. In the event of failure it is advisable to fix expanded metal to round steel rods stapled to the wall, or to use a ribbed expanded fabric. This will greatly strengthen the wall face.

A Good Key

A good key is essential. Joints should be raked out and brushed clean. Ashlar or other smooth wall faces should be hacked and the hacking undercut.

Chapter IX

SMOKY CHIMNEYS, DOWN DRAUGHT, ROOM DRAUGHT

THE causes of smoky chimneys are often obscure and so varied that a thorough investigation of each individual case should be made before deciding on treatment. Most treatment failures are due to the adoption of partially effective measures—usually having the one and only merit of cheapness.

PRINCIPLES

The simple principle of the chimney flue and fireplace is that hot air and hot gases tend to rise as they are lighter than cold air. The colder and denser air entering a room through ventilators or gaps between doors and windows and frames is at a higher pressure than the warm room air, and so forces the warm air through the fireplace and up the flue.

This process can be overdone. Too much draught causes the fuel to burn too quickly. Too little, on the other hand, may cause down draught (smoky chimney). The design of the fireplace, flue and chimney must be such that the right quantity of air and rate of draught is maintained under a wide range of atmospheric conditions.

Unfortunately, many fireplaces, old and modern, are not correctly designed, so that the smoky chimney is a widespread fault.

The Building Research Station investigated this problem and found that the principles of fireplace design laid down by Count Rumford in the eighteenth century are scientifically sound.

RUMFORD'S PRINCIPLES

These principles have been summarised by the Building Research Station as follows:

- (1) A throat perpendicularly over the fire 4 in. wide.
- (2) Splayed sides to the fireplace. Rumford suggested that in most cases the width of the back of the fireplace should be about one-third of that of the opening.
- (3) Sufficient depth from the wall face to the back of the fireplace to prevent smoking caused, for example, by draughts across the fireplace opening.
- (4) A horizontal smoke shelf at the level of the top of the throat, which should be a few inches higher than the top of the fireplace opening.
- (5) Smooth internal surfaces to all smoke passages and a rounded internal angle to the top of the fireplace opening.

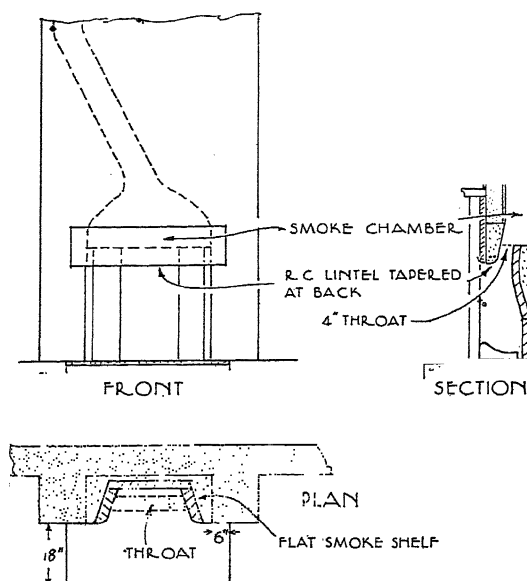


Fig. 41.—THE DESIGN OF A FIREPLACE TO PREVENT DOWN DRAUGHT

Rumford stated, too, that a sloped back improved the efficiency of the fireplace, but that, in order not to impede the rise of the smoke into the flue, the slope should be gradual, and should start immediately above the fire, terminating 8 in. or 10 in. higher.

The plan and section, Fig. 41, illustrate these principles about as far as they can be conveniently applied to a new fireplace with normal grate. They differ from conventional practice chiefly in the smoke shelf, the gradual slope of the fire back, and the

flue rising perpendicularly over the centre of the fire.

In practice it is usually necessary to bend the flue from immediately over the fireplace to one side of the chimney breast. This bend does no harm, but the angle should not be too sharp—not less than 60 degrees. From this bend the flue should run vertically to the chimney top.

FAULTS

The causes of down draught may be found in:

- (a) Wrong design of fireplace and flue.
- (b) Insufficient air supply to fire.
- (c) Cold, damp flues, due to lack of sufficient insulation or poor weather resistance.
- (d) External conditions creating an area of pressure at the chimney outlet.

Faults in Design and Construction

Any marked departure from the principles already described may cause down draught. A flue size of approximately 9 in. \times 9 in. is best for ordinary domestic fires. In old buildings much larger flues may be found, and these, with wide open, fireplaces usually cause down draught unless a big fire is kept going. Reduction of the size of the fireplace with the installation of a modern grate may cure the trouble, but it may be necessary to reduce the size of the flue by cutting out the wall at

the back or side and building up a thickness of brickwork from bottom to top—a rather costly job.

Sharp bends may impede the air flow and cause down draught. They are also awkward in chimney sweeping.

Pargetting and Lining

The traditional pargetting of a lime mortar with cow-dung admixture will probably have broken up and disappeared in an old flue. This may cause down draught, as some of the fallen material may lodge in bends. In any case, the bare walls of the flue will be rough and will easily gather soot. Nothing can be done about this short of opening the flue and re-lining.

Lime mortar or cement mortar is often used to line modern flues, but the mortar breaks up in time and may cause trouble.

The best lining consists of fireclay flue pipes or liners. These are obtainable round and square. They not only provide a durable lining, but increase the thermal insulation of the flue.

Chimney Pots and Cowl

The chimney outlet should be at least 3 ft. above the highest part of the roof adjoining the chimney, as shown in Fig. 42. If external conditions create an exceptional area of pressure, as in Fig. 43, the chimney should be higher than 3 ft.

Chimney pots are superfluous. They serve no useful purpose, and as they deteriorate they are a cause of trouble. A chimney pot may be used to increase the height of the outlet, but it is better to build up the chimney.

Patent pots and cowls designed to cure down draught are used with varying degrees of success. If the fault can be diagnosed with certainty

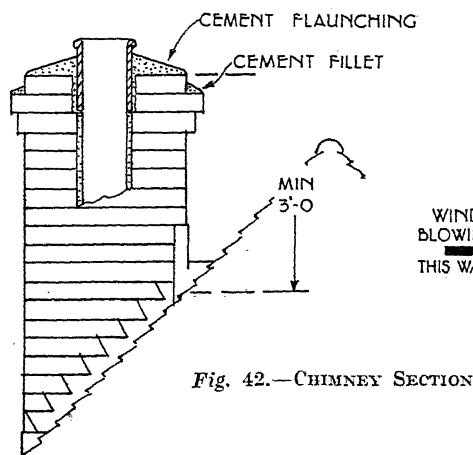


Fig. 42.—CHIMNEY SECTION

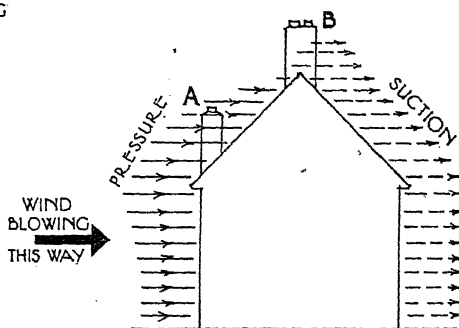


Fig. 43.—AREAS OF PRESSURE AND SUCTION. DOWNDRAUGHT PROBABLE IN CHIMNEY A, BUT NOT IN CHIMNEY B.

it is better to put it right, unless the operation would be very costly, when a patent pot or cowl might be tried first.

The experience of the Building Research Station is that the cause of trouble usually lies in the fireplace and immediately above it, so special attention should be paid to this.

Chimney tops with a slab top obstruct the outlet, and usually cause down draught.

Gas Fire Flues

The same principles apply to gas fire flues as to others, though a 9 in. \times 4 in. flue is sufficient. Special concrete blocks are made for building into the thickness of the wall. These are useful when adding fires, though asbestos-cement flue pipes can be used.

Special outlet cowls and baffles are made for preventing down draught. Occasional down draught is not so troublesome in a gas fire as in a coal fire flue and, for this reason, the chimney outlet is not always taken up above the roof.

Air Leakage

Air leakage from decayed flues can cause down draught, and may set fire to wood adjoining the chimney breast. This is due to decay of the flue lining and the joints of the flue withes and walls. In some

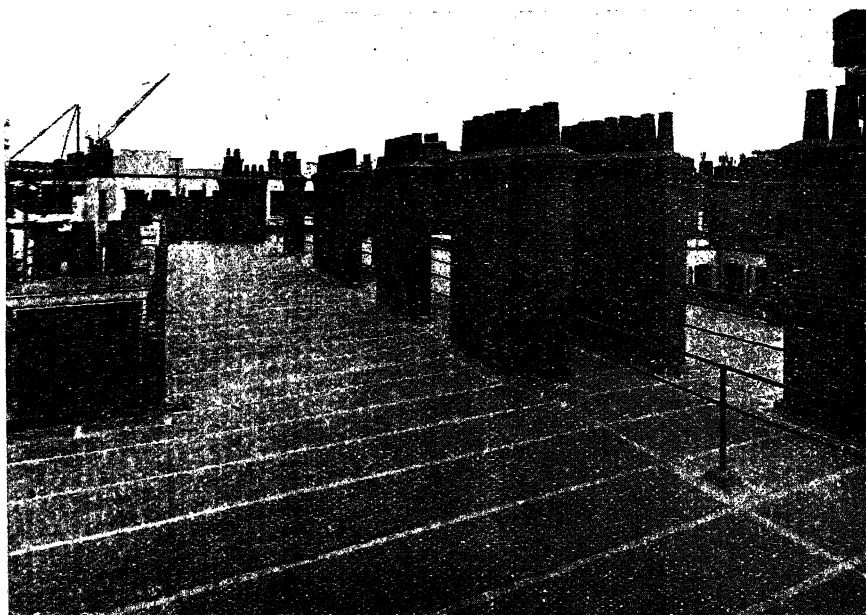


Fig. 44.—CHIMNEYS SHOWING POTS AND PROPERLY FLAUNCHED TOPS. THE FLAT ROOF IS COVERED WITH BUILT-UP RUBEROID ROOFING (*The Ruberoid Co., Ltd.*)

cases there is leakage from one flue to another. Reconstruction is the only remedy for decayed withes, though leaky joints in the outer walls of the flue can be deeply raked, filled with new mortar and pointed. In the case of $4\frac{1}{2}$ in. brickwork in chimney bond with thick joints of old decayed lime mortar it is possible to rake out the joint the full thickness of brickwork and make good, in small areas at a time. The interior joints can be smoothed by coring the flue as the work proceeds (passing a line from top of chimney to fireplace and attaching a ball of sacking—then drawing the ball up the flue to wipe off loose mortar).

Where the chimney above the roof is very badly decayed it should be taken down and reconstructed, using new bricks or stones where necessary.

The chimney top should be flaunched by providing a cement mortar finish sloping outward, as shown in Fig. 42. It is desirable to set the chimney pots at least two courses down. Brick bats can be used to form a roughly sloping surface preparatory to flaunching on a fine concrete. It is an advantage to use a waterproofer with the flaunching mortar. Fig. 44 shows well-flaunched chimneys.

Insulation and Damp

Down draught may be caused through the flue being cold and damp. This makes the air in the flue cold and heavy to start with, and tends to cool the smoke and gases near the chimney top so that the hot smoke below cannot force its way up.

The outer walls of chimneys should be 9 in. thick for good insulation, especially with tall chimneys. The lining of the flues with fireclay pipes greatly improves the thermal insulation. If an old chimney is taken down to roof level and reconstructed, it is worth while lining it with these pipes.

Dampness in a flue may be due to general decay of the chimney, or to the lack of a d.p.c. so that water soaks downwards. Pointing and flaunching and attention to flashings will put this right, though in some cases it may be necessary to insert a d.p.c.

EXTERNAL CONDITIONS

Wind striking a building creates an area of atmospheric pressure on the weather side and suction on the lee side, as in Fig. 43. If the chimney outlet is within the pressure area down draught may be caused. Adjoining buildings and trees may modify the pressure and suction. A safe rule is that whatever the position of the chimney, the outlet should be above ridge level, or above the level of any other building or tree in the vicinity. Thus, if a chimney is placed at the eaves of a pitched roof the top should be at least a few inches above ridge level.

Flat roofs are covered by an area of suction, but this may be less than the suction against the lee side wall and down draughts may result. So it is necessary to have a chimney height in the case of a small house

of about 6 ft. In the case of a large area of flat roof the height might have to be much more.

Where the design of the flue and fireplace appears to be sound, and there is no decay, down draught is probably due to insufficient height of chimney. Raising the chimney will probably cure the trouble. Tallboy pots can be added, but they are liable to crack, and have poor thermal insulation.

The presence of a tall tree may cause down draught by creating an area of pressure. It may be easier to cut down the tree than to raise the chimney.

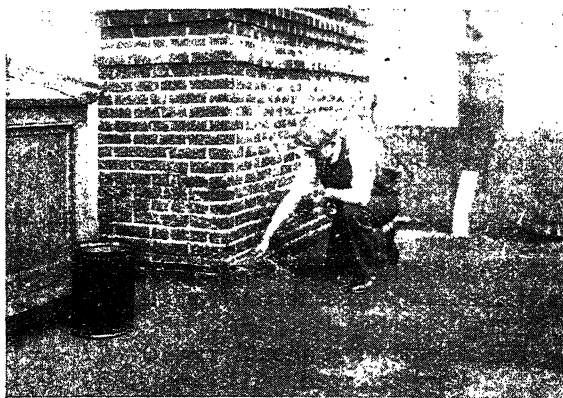


Fig. 45.—POINTING CHIMNEY WITH MASTIC "PLASTALEKE"
(George M. Callender & Co., Ltd.)

DRAUGHTS AND AIR SUPPLY

We have two problems together here: Troublesome draughts in a

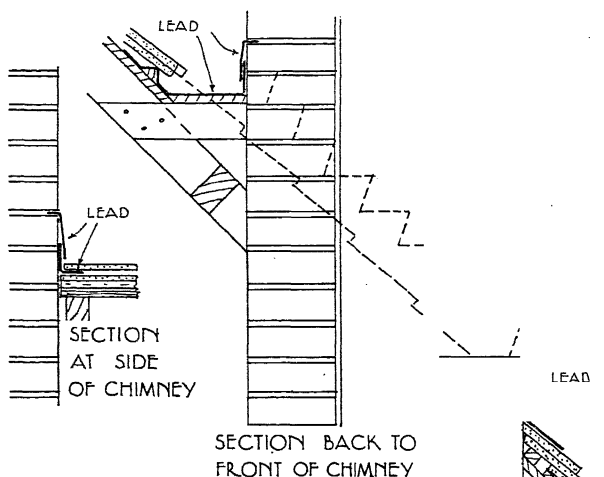


Fig. 46.—LEAD FLASHING TO CHIMNEY

room and air supply to the fire. The fire must have a sufficient supply of air. This may create troublesome draughts in the room—the air entering under and around doors and windows. If felt, rubber strip, etc., is fixed to reduce the draught, the air supply may be insufficient to carry the smoke up the chimney. The air pressure in the room will be lowered, and down draught will result.

This trouble is

best met by fixing a wall ventilator in such a position that air passes to the fire without crossing the room. An air brick or bricks, with adjustable vent covers can be fixed near the fireplace. Bad cases of room draught and flue down draught have been cured by this quite simple means.

If lack of air supply is the cause of down draught, the trouble is cured by opening a door or window—this can be used as a test.

The Flashings

Chimney flashings may admit damp causing the flue to become cold, and so to draw poorly. Pointing with cement or mastic, as in Fig. 45, may suffice, or the flashings may require renewal. Fig. 46 illustrates the arrangement of lead flashing to a chimney on a sloping roof.

The gutter at the back of the chimney may become blocked with leaves, etc., and such a stoppage will probably result in rainwater soaking the chimney brickwork or roof covering.

Chapter X

PATHS, DRIVES, PAVINGS, FLOORINGS

A SURFACE for foot or wheeled traffic should be selected to suit wear and other conditions of use, and many failures are simply due to the use of unsuitable material. The support (sub-floor or sub-paving) must be adequate for the traffic, and the nature and strength of the subsoil should be carefully considered, before finally deciding upon the surface to be adopted.

CONCRETE

As concrete is used under most pavings and floors, and is often used as a finished surface with no other coverings, it will be useful to consider this material first.

For path and floor foundations a rather weak concrete (1 part Portland cement to 6 parts sand and coarse aggregate) is often used. This is suitable on a firm well-drained subsoil, but on weak or damp subsoil it may crack or admit damp to the surface. This trouble may be cured by hacking off at least 3 in. of the existing concrete and replacing with a fairly strong concrete (1 part Portland cement to $1\frac{1}{2}$ parts sand and 3 parts granite chippings not larger than $\frac{3}{4}$ in. is suitable).

For foundations under drives and for under-floor concrete a 1 : 2 : 4 mix is generally suitable. For surface concrete for solid floors on damp ground the denser 1 : $1\frac{1}{2}$: 3 mix is better, and this mix is also a good one for the surface concrete of paths and drives. Two course work should have the stronger surface course at least 2 in. thick, and it should be placed on the lower course while the latter is still green (within half an hour of the foundation course being placed). The two courses will thus bond well together.

Dusting-up

Dusting-up is a common defect on concrete and cement bound floorings and pavings. The surface disintegrates, sometimes under very slight traffic wear. Good concrete properly mixed placed and cured, will not dust up under average conditions.

To prevent dusting-up use a moderately strong mix, such as 1 : $1\frac{1}{2}$: 3 with $\frac{3}{4}$ in. granite chippings as coarse aggregate. Do not trowel the surface much or neat cement will be drawn to the surface. This cement film, though it looks strong, is brittle and soon breaks up. The rather rough surface given by a wood float or tamping with the edge of a plank is a better wearing surface.

Curing

Curing is essential if dusting-up and cracking is to be prevented. This consists of retarding the drying of the concrete. One method is to cover the surface with a waterproof building paper or with clean sacking. Another is to spray the surface through a rose at intervals. In any case the surface must be protected from hot sun and drying winds. If building paper is used, the laps should be sealed, and the paper left in position until the building is completed.

Hardeners

Chemicals which can be mixed with the surface concrete or brushed into an existing surface to fill the pores and bind the particles are known as hardeners. There are many brands, and they should be used strictly to the maker's instructions.

Silicate of soda (waterglass) is a good hardener. The P. 84 concentrated solution is best for this purpose. It is an excellent treatment for a dusty or damp concrete floor or paving. Dilute with four parts of water and apply from a watering-can fitted with a rose, and then spread with a clean mop. Two or three applications will harden the surface to a depth of about $\frac{1}{4}$ in. Silicate of soda should not be mixed with concrete, but applied only on the surface after it has set. As an admixture it weakens the concrete.

Waterproofers and D.P.C.s

Hardeners, including silicate of soda, waterproof the concrete. Damp concrete floors can be waterproofed by surface treatment if there is no water pressure under the concrete.

In new work a horizontal d.p.c. may be laid between two courses of concrete. This will resist water pressure.

Reinforcement for Drives and Floors on Weak Ground

This is advisable to prevent cracking and settlement. This may consist of mild steel rods or a proprietary mesh. For heavy wheeled traffic on good subsoil, about $7\frac{1}{2}$ lb. per sq. yd. of reinforcement should be placed near the top of the slab, and the same weight for light or heavy traffic on medium strength subsoil. For heavy traffic on bad subsoil reinforcement should be placed both top and bottom of slab.

Expansion Joints

These joints are necessary in large areas of concrete to prevent cracking due to expansion. In plain mass concrete these joints should be placed to divide the slab into squares of approximately 25 ft. In reinforced slabs this may be increased to 50 or 60 ft. Expansion joints should be $\frac{1}{4}$ in. to $\frac{1}{2}$ in. wide according to size of slabs. Joints should be filled with bitumen or one of the proprietary asphalt fillers.

Placing Concrete

For drives, paths and large floor areas, erect thick boards at the edges held with strong pegs. These should be spaced the width or length of a bay, say 12 to 15 ft., and levelled to correct levels allowing for falls and camber. Use a tamper—of at least 7 in. \times 2 in. timber with handles at the ends and cut to correct camber for tamping the surface. For paths and drives this leaves a rough non-skid surface.

PATHS

The cheapest paths consist of furnace ashes or gravel spread and rolled on brick or stone ballast. In wet weather the loose material is picked up by shoes and wheels. Regular rolling is essential to keep such paths in good condition.

Concrete

One of the best path materials. Poured concrete paths should be at least $1\frac{1}{2}$ in. thick on hard well-rammed ballast. Lay in lengths of about 15 ft. and leave open expansion joints $\frac{1}{4}$ in. wide. Cure the surface, as previously described, and there will be no trouble with cracking. Cracking of such paths is usually due to lack of expansion joints and curing. Use a fine concrete with $\frac{1}{4}$ in. granite chippings.

Pre-cast Concrete Slabs

For paths and terraces concrete slabs may be bedded at the corners in a lime-cement mortar. This prevents rocking, which is a fault due to the slab being supported in the middle. The slabs are produced by numbers of firms in various sizes, $1\frac{1}{2}$ in. and 2 in. thick.

Stone slab paving can be laid in the same way.

Tarmacadam and Bitumen Bound

Paths of these materials provide a durable waterproof surface at moderate cost. The paths are laid in two courses: The foundation material has a coarse aggregate of stone or other material 1 in. to $1\frac{1}{4}$ in., and the finishing course $\frac{1}{2}$ in. thick, consists of tarred or bitumen bound granite chippings, $\frac{3}{8}$ in. rolled in. A final surfacing of very fine chippings or silver sand is then sprinkled over. Repairs are easily carried out with new material. There are firms in all districts specialising in these paths, though the material can be bought, and there is no reason why the repairer should not patch up defective patches.

Asphalt

Asphalt with chippings makes an excellent hard-wearing path. Repairs are easily carried out, but should be placed with specialist firms.

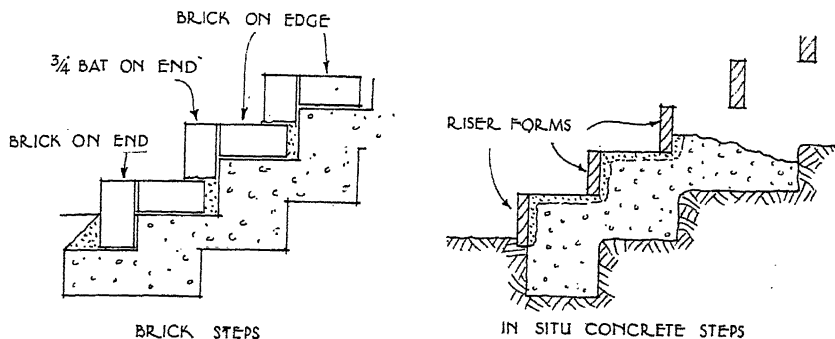


Fig. 47.—CONCRETE AND BRICK STEPS

Brick Paths

Bricks may be laid (preferably on edge) on well rammed and levelled subsoil, using lime mortar or sand for bedding, leaving a hollow bed under the middle of each brick to prevent rocking. They have an excellent appearance, especially when laid in patterns.

For terraces bearing much traffic and for steps bricks should be set in cement. A fault often arises in steps through the edge bricks working loose. The steps should have a foundation of concrete at least 4 in. thick, and the edge bricks should be held in mortar, as shown in Fig. 47.

Falls and Cambers

All paths, drives, and interior pavings, should be given falls and cambers, so that water drains off. A minimum is 1 in. in 10 ft. This should be set out with the level and straightedge. Clay and other damp subsoil should be drained, or the paths laid on a thick bed of dry ballast, such as broken brick or stone, or furnace clinker.

INTERIOR PAVINGS

Solid floors consist of concrete with a surface material cemented to it (except asphalt, which does not adhere but is laid on underfelted). The term pavings is used for hard, impervious surfaces.

Tiles and Quarries

Constructed of burnt clay, granolithic or composition they are laid on a cement and sand screed. The screed gives an even surface. The tiles should be laid before the screed sets on a bedding mortar about $\frac{1}{4}$ in. thick, consisting of 1 part Portland cement to $1\frac{1}{2}$ parts sand. Tiles and quarries should be partly soaked before laying. Cover the floor with building paper or sacking to prevent rapid drying, which might result in shrinkage of the mortar and loose tiles. For wide joints butter the mortar on the edges of the tiles. For thin joints grout after laying. All cement must be cleaned off before it sets.

In old buildings, quarries and stone flags may be found bedded in mortar on dry ballast, or even on earth. On a well-drained subsoil there may be no rising damp, but such a floor should be taken up and a layer of concrete at least 4 in. thick placed as a base for quarries or other paving.

Quarries and clay tiles sometimes wear very rapidly. When newly laid they should be soaked with linseed oil. An occasional rub over with linseed oil will keep the surface in good condition. They should not be scrubbed—this treatment roughens the surface.

Badly worn quarries can be restored by liberal application of Cardinal red floor polish, or by treating with a good brand of floor paint.

Efflorescence may appear on tile or quarry floors. The only treatment is to wash off with pure water, without using soap. But it may take some years to get rid of the soluble salts which cause the trouble. When most of the salts have been washed out, the tiles may be treated with linseed oil or a suitable polish or paint.

When renewing stone and marble slabs, obtain the slabs from a reputable firm specialising in these pavings. A soft stone or one that easily laminates is useless.

Granolithic

This is a strong concrete in which granite or whinstone chips are used as the coarse aggregate, the proportions being 1 part Portland cement to $2\frac{1}{2}$ or 3 parts chippings. For light wear conditions, the thickness should be 1 in. For heavy conditions $1\frac{1}{2}$ in. The chippings should pass a sieve from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. according to the thickness of the granolithic.

The chippings should be graded from small particles to the maximum size. Any dust should be removed by washing the aggregate. The surface should be trowelled smooth but not "ironed," or a weak mortar will be drawn to the surface. A hardener or silicate of soda may be used, as previously described, to give a dense waterproof surface.

Cracking of granolithic is due to shrinkage or expansion movements. Large areas should be divided into squares of about 15 ft. sides with expansion joints of bitumen.

Terrazo and Mosaic

Terrazo consists of marblé chippings rolled into a cement bed, the set surface being polished by rubbing with a weighted stone. Grit or carborundum is sprinkled on the surface before the material sets to make it non-slip.

Mosaic consists of small cubes and pieces of marble set in coloured cement. For flooring the design is transferred to a sheet of paper and the cubes of marble are stuck face downwards to it with adhesive. The "slab" is then reversed and laid on the cement mortar bed. The paper is washed off, and the mosaic is grouted to fill the spaces.

Terrazo and mosaic in large areas should be divided up into squares,

using brass strips or bitumen as expansion joints. Cracking is usually due to lack of such joints.

As terrazo and mosaic laying are specialist operations, repairs should be placed with specialist firms.

Linoleum Cork and Rubber

These materials are useful for laying in old buildings, or for replacing unsatisfactory floorings. They must have a reliable dampproof base. They can be laid on concrete or wood. Surfaces must be level and smooth. Special mastics are used for fixing. The work should be placed with specialists. Faults are usually due to damp rising through the sub-floor, or to cracks or warping of the sub-floor.

A rubber tile with a rigid asbestos-cement core is made. The rubber backing is keyed, and the tiles may be laid in cement mortar bedding in the same way as ordinary tiles. These tiles can be laid by anyone used to laying ordinary clay tiles.

Sheeting floorings are said to cause dry rot in a timber floor. But if they are stuck down with adhesive, and the joists and boards are properly ventilated under the floor, there is no risk of rot.

Magnesite Flooring

(Also called Jointless or Composition Flooring) consists of calcined magnesium carbonate mixed with magnesium chloride solution and a suitable aggregate (usually wood flour or sawdust). Silica, talc, quartz, and asbestos are sometimes added to give harder wear.

The composition may be laid in one or two courses, $\frac{1}{2}$ in. to $\frac{3}{4}$ in. thick, according to the wear it must stand. Laying and repairing should be placed in the hands of reputable specialist firms.

The sub-floor must be dry. Damp causes the floor to expand and break up. Excessive heat is also bad, and hot water pipes passing through the floor should be lagged. Acids eat into the material, but milk and fats do no harm.

Magnesite flooring can be laid on boards, using expanded metal or wire lathing as reinforcement. It is a good flooring to apply on old boards, provided they are dry and in sound condition.

BOARDED FLOORS

Deal or hardwood boards are nailed either on (a) timber joists, or (b) battens secured to concrete or hollow tile floors.

Ground floors of joists and boards must be well ventilated, and air bricks must be arranged in the walls so that there is through ventilation. Otherwise dry rot sets in (see Chapter XII). In repairing wood floors affected by dry rot, all infected timber should be removed and burnt and all sound timber treated with a preservative.

Floor boards are grooved and tongued, but in old floors plain edges are sometimes found. The chief faults in boarded floors (other than dry rot) are shrinkage resulting in the joints opening, and warping.

Shrinkage

Shrinkage may open the side joints as much as $\frac{1}{2}$ in. The best cure is to fill with wood fillets. If they cannot be nailed they should be glued with a waterproof glue. Very narrow gaps may be filled with plastic wood which, after setting, should be glass papered smooth.

Warping

The edges of the boards turn up and cause damage to the floor covering. The only treatment is to plane the upstanding edges until the boards are levelled. Punch down nail heads before planing.

The gap between shrunk skirting boards and the flooring is best covered with a small moulding nailed to the floor boards.

A badly worn boarded floor may be covered with plywood sheets secured with pins. Flooring firms supply special hardwood faced sheets for this purpose.

Parquet

And ornamental block floorings should be laid and repaired by specialist firms. A dry sub-floor is essential.

FLOOR STRUCTURE

Solid concrete has already been described. For ground floors it is 4 in. to 6 in. thick, and for heavy loads or weak ground should be reinforced with mild steel fabric.

Suspended concrete (upper) floors are of reinforced concrete slabs. All but small spans are supported on beams, either of steel or reinforced concrete. Large areas are subject to expansion cracking unless the expansion joints already described are used.

The best treatment for such cracks is to fill with bitumen, and so convert the cracks into expansion joints.

Ceiling cracks may appear on the soffits of concrete floors and beams. This is due to sheer stress and indicates that the reinforcement has not been properly designed. If the cracks are very fine, and do not widen, they may be disregarded.

Hollow Blocks and Beams

These are of burnt clay or pre-cast concrete, and are much used in modern buildings. Some are self-centering, i.e. they require no close boarded shuttering, and many require no temporary support of any kind. The reinforced concrete hollow, tee, and channel beams are useful for extensions and alterations. These beams and blocks can be screeded for a solid flooring, or clips can be attached to hold battens for boarding, as illustrated in Fig. 48.

Timber Joists and Binders

Usually found in the upper floors of old buildings. Apart from

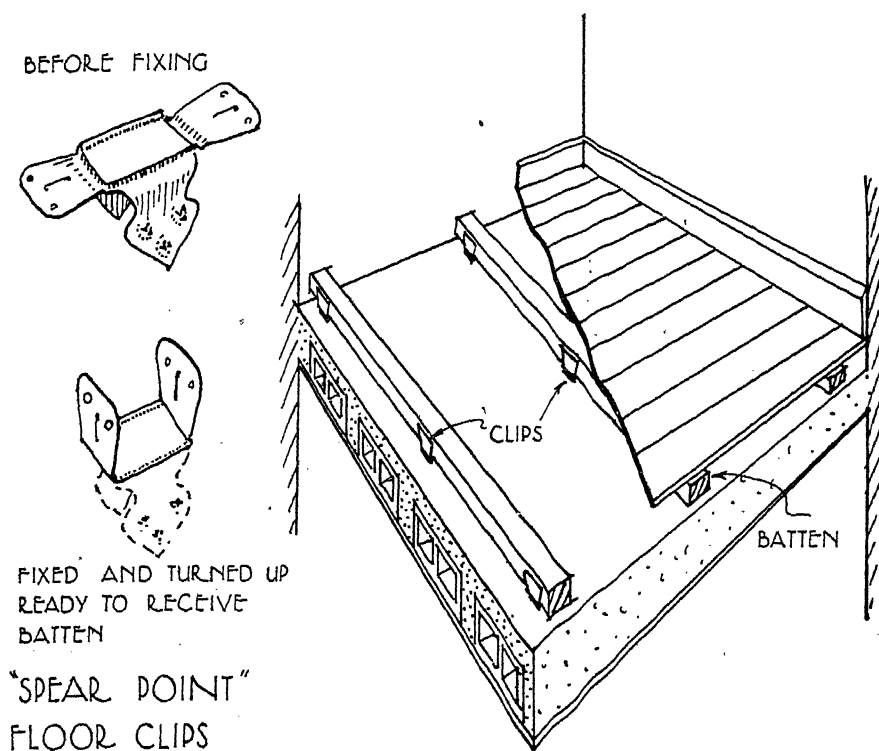


Fig. 48.—FLOOR CLIPS

dry rot (see Chapter XII), they may develop faults through settlement or bulging of the walls. Fig. 34 (bottom diagram) shows one such fault—the outward leaning of the wall leaves the joist ends in the air, or nearly so. If the wall cannot be restored to the upright, a beam should be placed as shown to support the floor joists.

Timber joists in some buildings are not deep enough for the span. Though safe, this may cause excessive deflection and crack plaster ceilings. The only practicable treatment is to replace the lath and plaster with fibre board (see Chapter VIII). Absence of strutting between the joists is another fault in some old buildings. This, too, may crack plaster ceilings, and also cause vibration when the floor is walked on. The boards can be taken up and solid or herringbone strutting inserted.

Chapter XI

JOINERY

IN this chapter we include doors and frames, windows, external joinery, staircases, and various internal joinery items.

The defects may be considered under the three following headings:

- (1) Shrinkage and warping.
- (2) Rot.
- (3) Mechanical failure of joints, plugs, etc.

PREVENTION

Both in new and repaired work precautions should be taken to prevent defects arising from the above causes.

Shrinkage of timber can be prevented by using well-seasoned wood, and by protecting it with paint so that the moisture content remains fairly constant. Timber may be well seasoned and dry when delivered, but, owing to the absorption of moisture on the site, it may be fixed while it contains an excess of moisture which on drying out causes the timber to shrink.

If possible, joinery should have a paint priming coat in the workshop, and this should cover backs and edges as well as visible parts.

Warping may occur in insufficiently seasoned material, but this trouble is primarily due to the boards and scantlings being incorrectly sawn. The annual rings should be approximately at right angles to the thickness, as in Fig. 49. If these ring markings curve along the width of the section, as in Fig. 49, the board tends to warp as shown.

Rot is dealt with in Chapter VII. Well-seasoned wood, protected on all surfaces by paint, will last for many years. But a damp stagnant atmosphere is favourable to dry rot. Ventilation and dryness is a better protection against rot than paint or preservative. Rot is often found at the backs of skirtings, in plugs, and the built-in horns of doors and window frames—all unventilated positions. At least two coats of paint on this concealed work would preserve it for many



Fig. 49.—EFFECT OF INCORRECT AND
CORRECT SAWING OF BOARDS

years, but, unfortunately, the concealed faces of joinery are often fixed without even a priming coat.

Mechanical failure in joinery is the same as that in carpentry, though the consequences are rarely serious. Joints open; or, if too highly stressed, fail by coming apart or breaking. Wood wall plugs shrink. These causes result in looseness and movement, the creaking of staircases, sagging, etc.

FIXINGS

The old type wood plug or block built in, or driven in, the wall for a screwed or nailed fixing is very unsatisfactory. At best its strength is uncertain. In time shrinkage occurs and it becomes loose.

Fibre and Metal Plugs

Proprietary designs should always be used instead of the old type wood plug. The Rawlplug is a well-known type. These plugs provide an efficient and durable fixing. They should be fixed in solid material—not in mortar joints.

Special jumping bits and wall boring tools are supplied by the plug makers, enabling holes to be rapidly and easily made. One advantage of these proprietary plugs is that the hole required is only slightly larger than the screw. As the screw is screwed into the plug, the plug expands and grips the surrounding wall material.

Fibre plugs are highly damp resistant, but for outside work rustless metal plugs are preferable. Both types are made in a large range of sizes. Typical fixings are illustrated in Fig. 50.

Bolts

Where heavy stresses are met bolts should be used. Machinery, heavy iron brackets, railings, balustrades, etc., should be fixed with some kind of bolt.

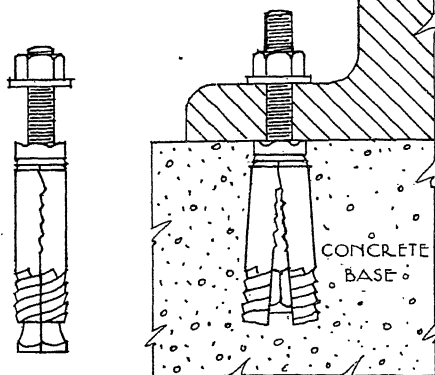
Washers and lock nuts should be used to prevent loosening by vibration.

Rag bolts are often used for fixing machinery, large signs, etc., to concrete and masonry. An undercut hole is made to receive the ragged end and the space between this end and the hole walls is filled with cement (1 cement to 2 sand) or molten lead.

Expanding Bolts

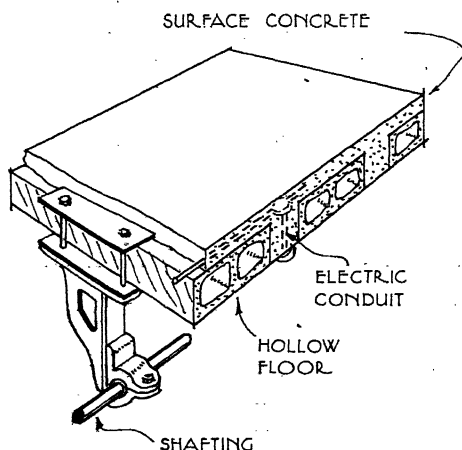
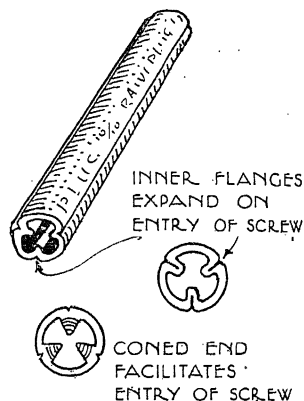
These are now largely used instead of rag bolts. (See Fig. 50.) As the bolt is tightened the expanding shell grips the wall of the hole. No filling is required. This is a more efficient fixing than the rag bolt. Two types are made—one with a loose nut and the other with a bolt head. The latter is used in fixing heavy machines, as the machine can be moved into position over the hole and the bolt then placed and tightened.

"RAWLBOLT"
BOLT PROJECTING TYPE

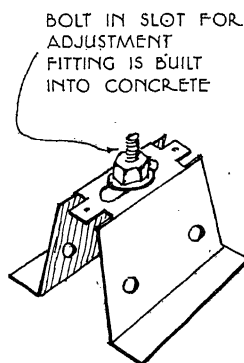


RAWLBOLT BEFORE AND AFTER FIXING SHOWING
EXPANSION OF SHELL IN FIXING HOLE WHEN
BOLT IS DRAWN UP

"RAWLPLUG"
WHITE BRONZE PLUG



FIXING TO HOLLOW UNIT FLOORS



"ANCORITE"
BOX FITTING FOR FIXING
TO CONCRETE FLOORS,
CEILINGS AND WALLS

Fig. 50.—FIXINGS FOR MACHINERY AND FITTINGS

Fixing Blocks

Blocks made of breeze, pumice or concrete, or diatomaceous earth,* take nails and screws, though the fixing is not so secure as when fibre or metal plugs are used. The fixing blocks may be built into suitable positions in the wall, bonding with the bricks or other blocks.

*A type of earth containing diatoms and silica used for fireproof cement.

For light fixings they are satisfactory. Two proprietary fixing boxes and clamps are shown in Fig. 50.

DOORS AND FRAMES

The framing joints of doors become defective if the paintwork is neglected, and moisture soaks into the joint. Wedges in mortice and tenon joints loosen, and as the joints are in tension the tenons pull out of the mortices. To restore the joints, remove the door, pour waterproof glue into the open joints and cramp up until set. It is advisable to fix hardwood pegs through the mortice and tenon joints of wide or heavy doors.

Wide doors, such as garage doors, should be braced, and the braces should be placed diagonally with the lower end on the hanging side of the door, so that they are in compression and prevent the opening edge from sagging. If unbraced doors are found to sag owing to their weight, braces may be screwed on.

Match boarded doors sometimes shrink and the tongued and grooved joints open. A slight opening can be stopped temporarily with plastic wood, but the best treatment is to fix vertical fillets to cover the joints, bedding them in thick paint or white lead, as in Fig. 51 (A).

Rainwater blowing under a door is a common trouble. A weathered and throated moulding should be fixed to the bottom rail, as shown in Fig. 51 (B), with a threshold bedded and fixed to the step. It is advisable to groove the threshold and step and fix a weather bar, otherwise rain-water may penetrate between step and threshold.

If rainwater penetrates the top of a door, a weather moulding with a good projection should be fixed over. If the brick head or

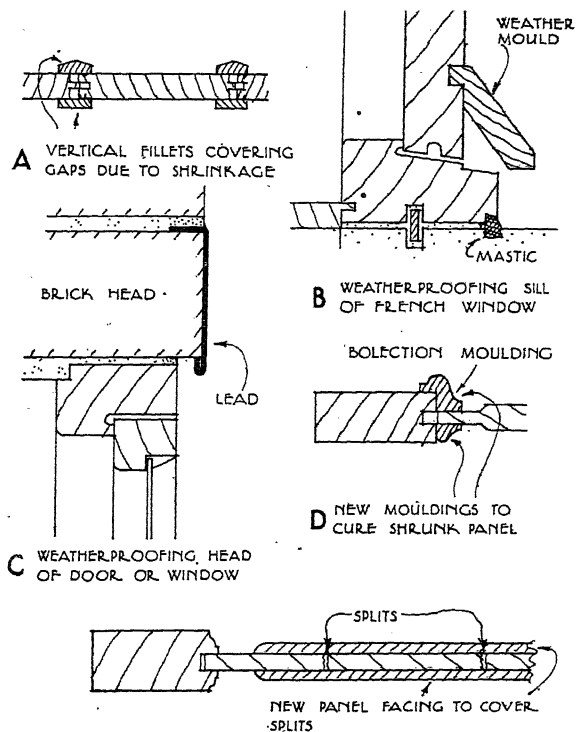


Fig. 51.—REPAIRS TO DOORS AND WINDOWS

arch admits water, a lead flashing should be placed, as in Fig. 51 (c). In a very exposed position a canopy or even a projecting porch may be necessary to keep the weather out. The penetrative power of gale-driven rain is so great that the repairer should beware of guaranteeing a cure by any inexpensive means.

Any weather moulding or canopy added to the wall over a door or window should be properly flashed with lead, zinc or copper, the flashing being turned into a bed joint and wedged and pointed.

Any extensive rot in a door involves at least one rail and stile. Although repair is possible, with the ordinary deal door it is cheaper to replace with a new door. With an oak door, or heavy garage doors, the decayed members may be removed and new ones made and jointed.

Warped doors leave wide gaps between door edges and frame, and so admit the weather. The warping cannot be corrected, but the frame rebate may be cut to make a better fit.

Door Panels

Door panels may shrink until the panel tongue comes out of the framing grooves. The best cure for this is to fit a bolection moulding all round the panel, as in Fig. 51 (d). This covers the gap and strengthens the panel fixing.

Split panels may be repaired by covering with fillets, and sometimes by covering with a thin panel slightly smaller than the door panel, as in Fig. 51 (bottom). Both fillets and panels should be designed with consideration for the appearance.

Large panels are sometimes built up with grooved and tongued boards. Shrinkage may open the joint and reveal a gap. This may be filled with plastic wood, or covered with a fillet.

Door Frames

The usual fixing is by dowelling the feet to the step and building in the horns projecting on each side from the head. Unfortunately, rot easily occurs in both positions. A loose frame may be secured by drilling holes of sufficient diameter to enable a plug hole for a fibre or white metal plug to be jumped into the wall jamb. A plug can then be placed and the frame secured with a screw.

Lengths of a frame which has rotted can be cut out and replaced with a new length. There is some difficulty in jointing the new to the old unless the frame is removed. A groove can be cut in the frame, using saw and chisel, and a tongue can be formed on the new piece. The joint can be put together in white lead or waterproof glue, the new piece being plugged to the wall, as in Fig. 52 (A).

A sagging door frame head is sometimes found in wide door frames where the wall has been built on the head without lintel support. Fig. 52 (B) shows how under the conditions shown a lintel may be added to prevent further sagging. This trouble usually causes settlement and cracks in the wall above, for which there is no proper remedy short of reconstruction.

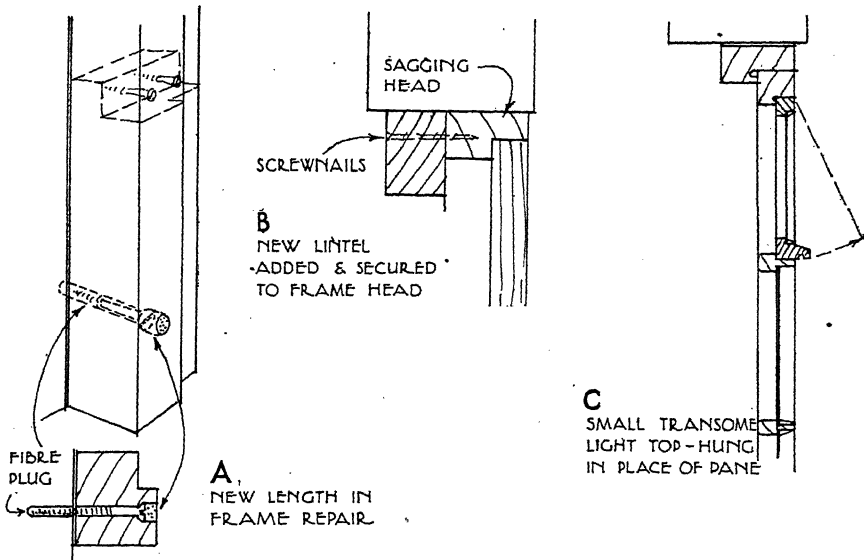


Fig. 52.—REPAIRS TO FRAMES AND WINDOWS

WINDOWS

Neglect of painting leads to loosening of the joints, as with doors. Such casements may be taken out and cramped up if they are not too bad. But any badly decayed or warped casement should be scrapped.

Where there are insufficient opening casements, a small top-hung light may be fixed in place of a panel, as in Fig. 52 (c).

Weather leakage between a hinged casement and the frame is due to shrinkage or warping, or sometimes there is nothing the matter with the window except that it cannot keep weathertight against exceptionally heavy gale-driven rain. The remedy in such a case is to add more weatherchecks.

Weatherchecks consist of grooves which prevent water moving through by capillary attraction. On reaching the groove the water drains down it to the sill and runs off the weathering. Another weathercheck is the rebate which, in conjunction with a groove, prevents rain-water driving in. Weatherchecks can be devised using bent zinc sections in grooves.

In existing hinged casements a cover fillet may be added to top, bottom, and opening edges, but not to the hinged edge. The cover fillets should be grooved, as shown. The bottom rail of the casement can be fitted with a weather moulding, so that it overlaps the sill and throws the water off.

Weather mouldings can also be added to the heads of frames or the wall head or lintel over. These should be covered with lead, copper, or zinc flashed into the wall or frame joint.

BUILDING REPAIRS

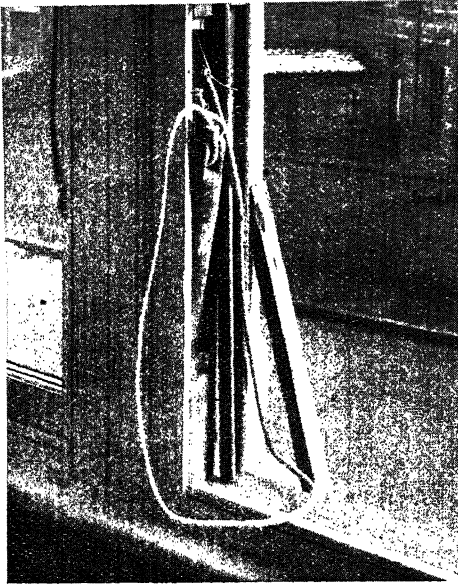


Fig. 53.—POCKET REMOVED SHOWING SASH WEIGHT (Photo: L. E. Walker)

Vertical Sash Windows

These windows rarely admit weather unless they are decayed or have warped badly, in which case the defective parts should be renewed.

Replacing Sash Cords

In vertical sliding sash windows this is a common repair job. The pulley stiles are fitted with pocket pieces, rebated and screwed. These are removed to give access to the sash weights and cords, as in Fig. 53. The inside and parting beads must be removed, as in Fig. 54, so that the ends of the new cords may be attached in the grooved sash, about half-way up the sash. Each new cord may be fitted separately, but to renew all four cords the following method is much better.

HOW TO CORD A WINDOW SASH

There are several ways of doing this job, but the following method recommended by James Austin & Sons, Ltd., cord manufacturers, has been found by the author to be the most practical and economical:

Fig. 55 (A).—Lower top sash and cut unbroken sash line at A. Gently ease out beading B with chisel at the middle, and then at the other nails. When sufficiently loose, grasp firmly with the hand in the middle and pull out. Remove both sides, and the lower sash will come out. Proceed with the next beading in the same way

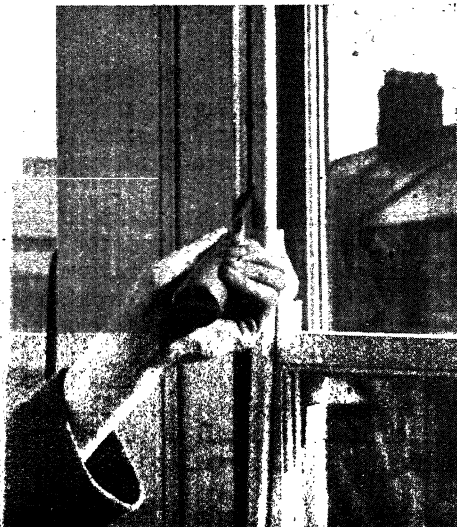


Fig. 54.—REMOVING INSIDE BEAD OF SASH WINDOW (Photo: L. E. Walker)

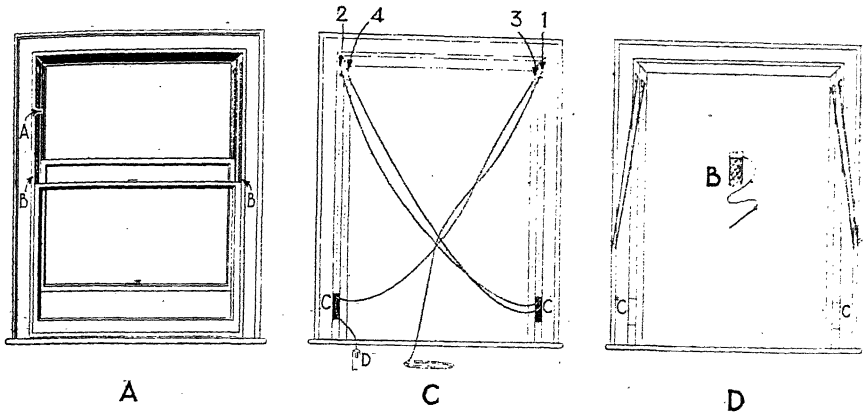


Fig. 55.—RENEWING SASH CORDS

(this should not have any nails in it), and remove the top sash. Take out the old sash line, clean up sash and put on one side.

Fig. 55 (B).—With a sharp knife cut an inch off the frayed end of the sash line and tie the loose end of the mouse in a slip knot round it (the “mouse” is a nail tied to 2 yds. of strong twine).

Fig. 55 (C).—Ease out covering of side boxes *C*, and remove sash weights. Repeat cleaning, etc., as before. Loosen about 24 yds. of new sash line and stretch it to its utmost capacity by tethering one end to a post and the other end round the body, throwing all weight on to it. Push the mouse over pulley No. 1, and when it appears below at the opening of the box, pull gently until sash line is safely through, and carry on to pulleys 2, 3, and 4. Remove mouse from end and put line through the sash weight *D*. Fix with a knot and place in the box. Draw weight up to the top and hang on with all your weight to settle the knot and again stretch your line. This will be the left line of the top sash. Proceed in the order given: 1, 2, 3, 4.

Fig. 55 (D).—Measure each line to about three-quarters of the length of the whole window, and place a nail through the line in the crevice of any fancy work round the window; then cut the lines. After this, place the line in the groove of the sash, and fix with three clout nails. Replace each part in the opposite order to taking down.

The above method has the advantages over others of easy manipulation, saving of time, labour and line, which is not cut until stretched, and the exact length is measured in the groove of the sash.

If the best sash cord is used, of the correct size for the pulleys, they will last for many years. Complaints about frequent breakages are due usually to the use of poor quality sash cords. If the pulleys are defective replace them with pulleys of good quality and correct size.

The length of the cords must allow the sashes to slide up and down without the weights touching the sill or the pulleys. If the counterweight

is the same weight as the sash, the latter will slide easily, and remain in any position.

When renewing sash cords examine the pulleys. If these are badly worn replace with new.

Rustless sash chains are made which can be used instead of cords. If chains are found to be working stiff, there may be paint on them (this is a point the painter should watch).

Window Frames

Frames may rot owing to damp penetrating between wall and frame. This especially applies to the sill. A badly decayed frame should be removed. Sills should be fitted with metal weather bars bedded in white lead or proprietary mastic.

For methods of dealing with the gap between frames and jambs, see page 37.

If the gap is wide, it is advisable to plant a scotia or other cover moulding over it, bedding it in mastic.

Metal Windows

Defects in this type of window are rare. They may be damaged by hard knocks, or the painting so badly neglected that the putty cracks and rust develops, cracking the glass. There are sometimes faults due to poor workmanship, though reputable makers of steel window are consistently reliable. Steel windows can be obtained rustproofed by sheradising, parkerising, or similar process. This is well worth the extra cost. Paint is slightly damaged where the steel sections make contact, and any extensive corrosion interferes with the closing of the casement. All rust should be scraped off before repainting.

Steel windows of the standard cottage type are best fixed in wood frames (or wood surrounds). This gives some protection during transport and fixing, and also a better appearance.

Steel windows will not support any wall load, though if set in wood frames the mullions will usually support the front of the wall if set at centres not exceeding 2 ft., the back being supported by a lintel. Any load on the steel casement may bend the frame and prevent the casement opening or closing.

The space at the back of a steel window frame should be filled with the mastic supplied by the makers. Re-pointing around frames should be done with a bituminous mastic. Steel windows are fixed to wood with screws, and to brickwork or masonry by building in lugs or by screwing to fibre or metal plugs in the wall jamb.

French Windows

The defects of french windows have already been described under windows and doors. The sill and the meeting stiles are the most troublesome parts. Special precautions should be taken to prevent

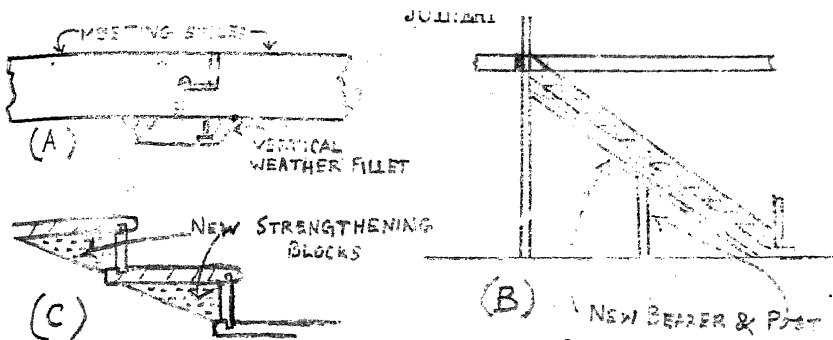


Fig.56--(a) Adding weather fillet to meeting stiles of French window. (b) Strengthening stairs. (c) Blocking treads and risers.

the weacher driving through these points. A metal weather bar in the still is essential, and the sill should be of hardwood. In an old window the sill is often rotten. The meeting stiles are rebated, and if the door has warped the rebate may not keep out the weather. Something may be done by cutting the rebate to make a better fit, but a well-fitting cover moulding, as in Fig.56(A), screwed to one of the meeting stiles, and bedding it in white lead or thick paint, is an effective weather check. The cover moulding should be grooved on the closing edge as shown.

Steel french windows are now widely used, and unless very roughly treated will retain their weathertight properties. A special steel threshold is used.

SKIRTINGS

The defects of looseness and rot are common. Dry rot may attack the back of the board, and is usually accompanied by dry rot in the timber floor. The whole of the infected timber should be removed (see Chapter XII). A blow-lamp flame should be played over the wall to kill the spores--otherwise they would infect the new skirting.

The best method of fixing skirtings is to first fix wood grounds to wall plugs, the grounds being the thickness of the plaster. Looseness is due to shrinkage or rot of the wood plugs. The skirting should be removed and the grounds properly secured, using fibre plugs and screws.

Some skirtings are fixed direct to wood plugs, but this is not satisfactory. In repair work proper grounds should be made and fixed, using fibre plugs.

Exterior angles should be mitred. Interior angles should be scribed. An interior mitre looks unsightly as the wood shrinks.

Window Boards

These are tongued into the window sill and secured to plugged grounds. These grounds loosen if ordinary wood plugs are used. In repairing use fibre plugs fixed in the bricks, not in the mortar joints.

These fixing methods apply generally to all light joinery items fixed to walls.

On wood partitions joinery can be nailed or screwed to the studs and plates, but grounds are necessary to make up the plaster thickness.

Shelves

Fix shelves on wood or metal brackets, or in some positions on ledges. These supports should be fixed to the wall by using fibre plugs and screws. Loose fixings are due to the old type wood plug. Brackets, whether of wood or metal, should be strong enough for the width of shelf and its purpose. For lightly loaded shelves, 1 in. thick by 9 in. deep, supports at 4 ft. centres are sufficient, provided the back of the shelf is supported on a wall ledge. Ends abutting on walls should be supported on short ledges.

STAIRCASES

A common fault is the squeaking of treads when walking on the stairs. This indicates either loose jointing to the strings or some defect in the carriage joist which supports the centre of the stairs. In cheap work this carriage joist and the blocks supported on it are omitted. Squeaky stair treads can usually be cured by re-blocking the underside from the existing carriage joist, or by adding a carriage joist and blocks, as in Fig. 56. This gives firm support where it is most needed. If the existing carriage is long, and lacks stiffness, a centre strut should be added. Squeaking in individual treads can be cured by blocking with stout triangular blocks, as in Fig. 56.

Wall strings secured to wood plugs in the wall may loosen through the plugs working loose. The simplest way of securing the string is to drill a hole so that a hole can be jumped in the wall, and a fibre plug inserted. A screw with a half round head and washer can then be used to make a fixing.

Chapter XII

DRY ROT AND INSECTS IN TIMBER

TO keep timber in a healthy condition it must be protected from damp, and the air around it must be well ventilated. Light, too, is desirable. Unfortunately it is difficult to secure these conditions in a building, and in the past through ignorance or carelessness, much timber was fixed in positions where rot or insect attack could develop under favourable conditions. Faulty fixing methods are still sometimes used, and dry rot may be found in recently erected buildings.

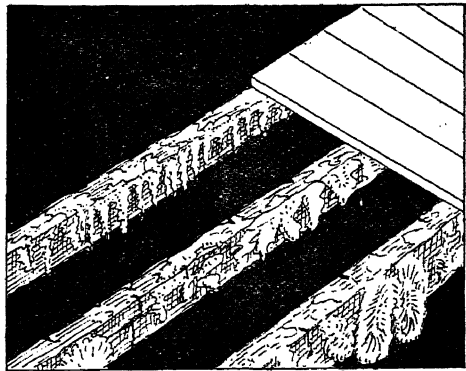
DRY ROT

This is caused by fungi (*merulius lachrymans*, *coniophora cerebella*, *polyporus vapor arius*, *lentinus lepideus*) which by means of an extensive root system extract a large portion of the mineral content of the timber. This turns the wood to dust, it loses strength, and if left under load will finally collapse.

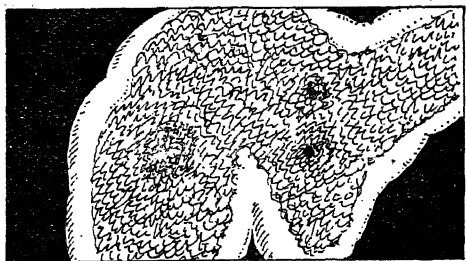
Fungi are capable of rapid growth and reproduction. They are propagated by spores which can be conveyed long distances by air currents, or by attaching themselves to tools, boots, etc.

Fungi

Of the four varieties which attack timber, *merulius lachrymans* is the most common. The spores develop into a soft white spongy growth, which is tender and may be easily blown away. Yellow and brown veins then develop, which assume a folding form and exude drops of water. If conditions are suitable the fungus grows to a large size, developing large rounded masses with flat areas of a leathery nature. The propagating spores come from the middle of the bunch. Fig. 57 is typical, though the fungus takes various shapes.



DRY ROT IN JOISTS



SPORE BEARING PORTION OF FUNGUS

Fig. 57.—DRY ROT FUNGUS

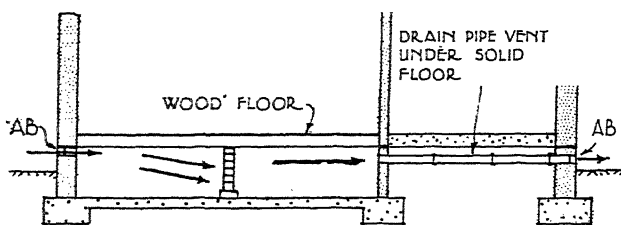


Fig. 58.—VENTILATION OF WOOD FLOOR

Treatment

Once timber is attacked by dry rot there is no cure. The infected material must be taken out and should be burnt at once to prevent the spores being car-

ried to other timber. Preservatives will not cure dry rot.

If only a small amount of timber is affected, remove and burn it. Then brush the remaining timber with preservative, such as creosote or a proprietary preservative, and brush into the brickwork too. The spores may be in the brickwork, and it is essential to kill every spore or the sound timber will be infected.

If most of the timber is affected, remove the lot. Before fixing new timber, go over the surrounding brickwork with a blow lamp. This will kill any spores. Brush preservative into the new timber.

Prevention

Dryness and ventilation will prevent dry-rot. Ground floor joists and boards are in a particularly vulnerable position. Before replacing a floor infected with dry rot, look to the ventilation, the d.p.c., and the under-floor concrete. If there are any faults put them right before fixing new timber.

Air bricks should be placed front and back, and along the sides if necessary, to give through ventilation. One air brick to every five feet is about right. If there is a solid floor adjoining, glazed stoneware drainpipes should be built under the solid floor to connect with air bricks on the opposite side, as in Fig. 58.

Joists must be placed above the d.p.c. (see Chapters V and VI), so that they are protected from rising damp. Joist ends should have a free

air space around them, and where they are built into the walls a pocket should be formed. It is always advisable to soak the joist ends with preservative as ventilation here is not very good.

Bad and good practice in supporting wood joist

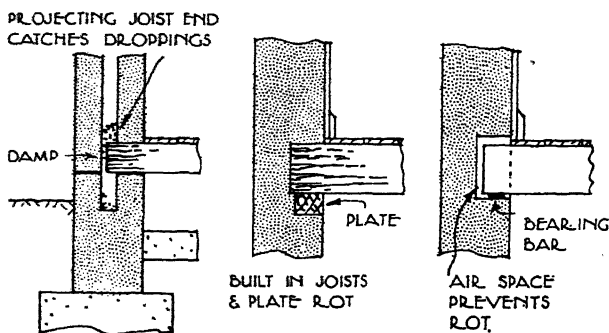


Fig. 59.—END SUPPORTS FOR WOOD JOISTS

ends are illustrated in Fig. 59.

Wall plates should not be built into the wall. This is now prohibited in most building by-laws. Plates rot in this enclosed position and may endanger the wall. They should be removed and the space made good with brickwork.

Roof torching under tiles sometimes causes the battens to rot. Ridge tiles bedded in mortar may cause the wood ridge to rot.

Frames in old buildings are usually rotten under sills, the sides of wall mullions, and the top of heads, and the top of horns, also built-in horns. Fig. 60 (A and B) shows two of these points. Unfortunately wood frames

are not properly painted where they are in contact with the wall, and even in frames only a few years old rot may be found, though concealed behind external paint. If wood cannot be kept dry and well ventilated it should be protected with paint or preservative from the start.

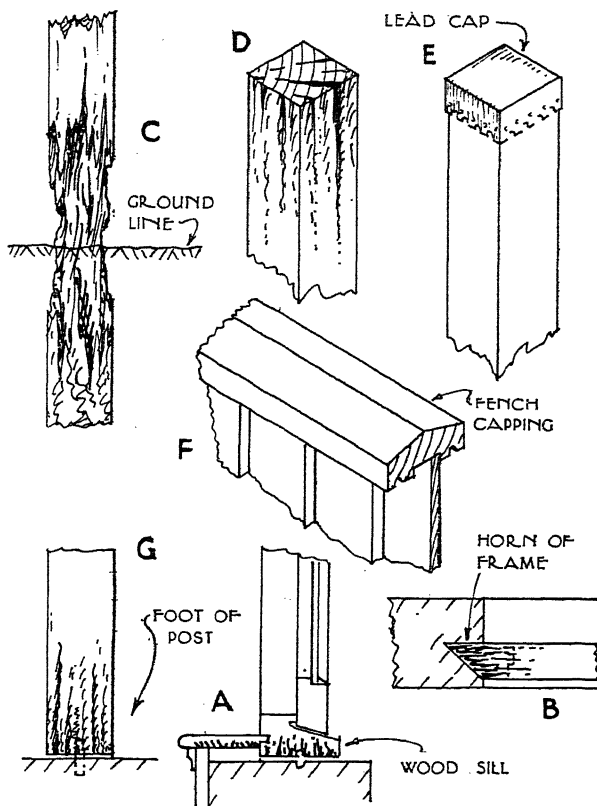


Fig. 60.—WOOD ROT IN VARIOUS POSITIONS

ROT IN OUTSIDE TIMBER

Waste of timber in fencing and garden sheds due to the rot which rapidly sets in is considerable. Timber, such as fencing posts, in contact with the ground is particularly vulnerable.

Posts in the ground rot rapidly from about a foot above to a foot below ground—though it soon spreads beyond this level, as in Fig. 60 (C). The tops of unprotected posts also rot rapidly, as in Fig. 60 (D). A lead cap, as in Fig. 60 (E), provides good protection, but it should not be placed over timber which is already rotten. Boarded fencing should be protected with a saddleback capping, as in Fig. (60 F). Porch posts rot at the foot

where water is easily absorbed. In new work the foot of the post should be raised on a concrete base and bedded in white lead or thick paint. In old work the gap at the foot should be pointed with thick paint or mastic, providing the wood is not already rotten.

Preservative Treatment

It is surprising that simple brush treatment with creosote is still common for exterior timber. It is almost useless for this purpose, unless renewed every year. Even so, it is useless to apply preservative to damp timber.

Creosote and any other tar oil, is much more effective if applied hot—at about 140 degrees Fah. The wood should be dry and clean.

Timber for damp or exposed positions (e.g. fencing posts) should be treated in a tank. Immerse the timber in cold creosote and then heat gradually up to 180 to 200 degrees Fah, and maintain this temperature for one or two hours. Keep the timber submerged until the creosote cools. This treatment will preserve the timber for at least ten years.

Pressure treatment is the best known. This forces the preservative into the interior of the wood. Some of the leading timber merchants have suitable plant and can supply pressure-treated timber to order.

A simple method of preserving post stumps is by charring in fire. This is an old treatment. Let the exterior char from the bottom of the stump to about 12 in. above ground level, but do not let the timber burn far into the interior.

There are numbers of proprietary preservatives, brush applied, which are good, but for fencing and other exposed timber, pressure treatment with tar oil is the best.

Some of the proprietary preservatives lack the rather offensive smell of creosote. Some can be painted over. Creosote and other tar oils bleed through paint.

INSECTS IN TIMBER

Insects of the beetle family attack timber in a dry state rather than a damp, and ventilation makes no difference. Consequently, timber in old buildings, even open ceiling and floor beams, is often badly decayed through insect attack.

Timber Boring Insects

Wood is used for food, shelter, and breeding by these insects. They bore holes along the direction of grain until the wood is almost completely converted to dust or "frass," as it is called. Obviously timber under load will collapse if this goes on long enough.

Insects are not often found in the timber of new buildings, but are common in old buildings. The symptoms are: surface holes, the deposit of frass dropped from the holes, and the tick or tapping sound made by certain insects as they cut through the wood.

The Death Watch Beetle

This beetle attacks structural timbers. It is rarely found in furniture. It does an enormous amount of damage in old buildings. The damage caused by this insect to Westminster Hall roof cost £100,000 to put right.

The death watch beetle lays eggs in small crevices and joints. The female lays about 18 eggs at the end of June, and two to four weeks later the larva hatches out and immediately commences boring into the wood. The diameter of the hole increases as the larva grows. The larva bores leisurely along the grain and, if it meets another piece of timber jointed at right angles, it turns the corner and bores along the grain of the second piece.

When the larva is ready to enter the chrysalis stage, it turns towards the surface, stops, and seals the boring. After three weeks as a chrysalis it emerges as a beetle, making the familiar tapping sound. The female beetle starts the life cycle over again by laying eggs in joints and crevices. The life cycle takes from two to three years.

Lyctus Beetles

Lyctus brunners, and *Lyctus linearis* are the two varieties of this beetle commonly found in Britain. They are not quite as common as the death watch beetle, but they live in the same way, and are equally destructive.

The Furniture Beetle

(*Anobium punctatum*). This insect works and lives in much the same way as the death watch beetle, but confines its attention to furniture and panelling. The life cycle occupies one to two years.

The Powder Post Beetle

A beetle that attacks hardwoods only, usually during the seasoning period. It has a life cycle of about one year, and though rather rare is very destructive.

Marine Worms

Timber in contact with sea water is liable to attack by these worms. There are eight species, the most common being the terados, of which there are three kinds. The terados vary from a few inches to 3 ft. in length. They bore into the timber in all directions, and as they seal the surface holes detection is difficult. They are rare in British waters.

Ants

Ants do little damage in Britain, but cause enormous destruction to timber in tropical climates; the termite or white ant is especially destructive.

The European ants which attack timber are called termes. They attack oak, fir, and olive. They are rather rare in this country.

Treatment

Timber seriously infested and weakened by insects should be removed and burnt. In buildings of historic and architectural value it is worth while making an attempt to eradicate the insects, provided the timber is not considered too weak for the load. In some cases steel rods and straps may be used to strengthen it.

The effectiveness of preservatives and chemicals depends upon the degree of infestation. It is very difficult to kill all the insects in badly infested timber owing to the difficulty of reaching every insect with the toxic chemical. The problem is one of penetration.

Creosote and other tar oils can be used on structural timber, and though good as preventives, have little value as cures. One brush application is useless, but repeated applications over a long period may reduce the number of insects, and prevent the hatching of eggs.

Dichlorobenzene has a rapid toxic effect on the insects.

Sodium fluoride in solution (three to six ounces to 1 gallon of water) is good, and its effectiveness is increased by adding salts of dinitrophenol. Two or three coats should be applied, and the treatment repeated at intervals.

Magnesium silicofluoride in solution ($\frac{1}{2}$ lb. to 1 gallon of water) is also good, but as an acid it attacks metals and glass.

The above chemical solutions are colourless and may be painted over when dry. They are suitable for interior use only, as they are washed out by water. They can be used on furniture. The undersides of table tops can be treated, and the insides and backs of wardrobes, etc. The solution can be squirted into holes with a syringe. Table legs can be left standing in jars of solution.

It helps to reach the insects if heavy sections of structural timber are bored in a diagonal direction from the top to the middle. The holes can be filled with preservative or solution and plugged. They should be refilled at intervals.

There are several good proprietary chemicals and preservatives. But in infested timber the difficulty is always in reaching the insects inside.

Avoid strong acids and poisons; vitriols, zinc chloride, corrosive sublimate, etc. Salt, lime, formalin and acetic acids are useless.

Chapter XIII

PITCHED ROOFS. SLATING AND TILING

DEFFECTS in pitched roofs may be due to:

- (1) Decay of roof timber or corrosion of nails, failure of joints, etc.
- (2) Deflection of weak roof timbers.
- (3) Unsuitable roof covering details.
- (4) Decay of covering or of fixing.

An old roof can hold some nasty surprises. What appears to be a matter of a few tile or slate replacements may actually involve the whole roof covering, or it may be found that the roof framing is badly decayed.

THE ROOF FRAME

If possible the roof should be inspected from underneath. From here it can be seen if there are any defects in rafters, purlins, struts, battens, torching, etc.—defects which might not be apparent from outside.

The rafters of a roof exert a side thrust on the walls—tending to push the walls outwards. This is usually counteracted by ties or ceiling joists acting as ties, as in Fig. 61 (A). But in small span roofs there may be no ties. If the walls have decayed the thrust of the rafters may cause the walls to spread and the roof to sink. This should be remedied by fixing collar ties across the rafters—the lower down the rafters the better.

Failure of timber roof frames vary from slight deflection, sufficient to open gaps in the roof covering, to complete collapse. Excessive deflection or sagging is common in old roofs. This may be due to decay of the timbers or failure of the fastenings due to corrosion of spikes and nails, and rot of pegs. Where sagging is found in new roofs, this

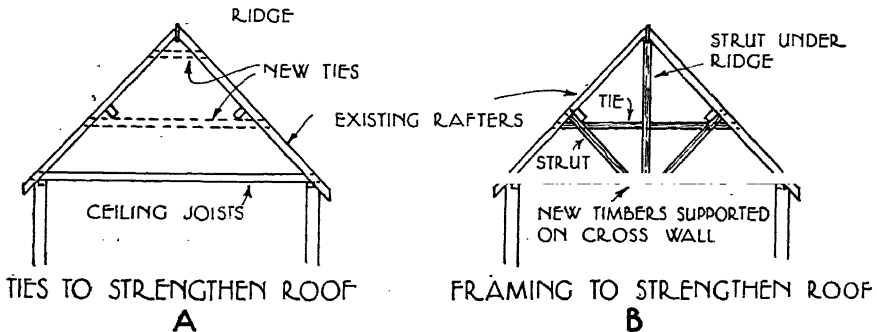


Fig. 61.—STRENGTHENING FRAMING

is almost certainly due to rafters or purlins being too light for the span and weight of covering.

Fig. 61 (A) illustrates methods of strengthening roofs by adding collar ties. In some cases such collars may be fixed to every fourth pair of rafters.

In other cases it may be necessary to truss the roof, as shown in Fig. 61 (B). This makes a triangular frame which is rigid and prevents deflection and spreading of rafters. Struts may be added to support purlins from partition walls.

These measures will arrest the spreading and settling of roof timbers, but will not restore the roof to shape. If the settlement has caused leaks in the covering it will be necessary to attend to this, but the strengthening of the roof should be undertaken first.

Common faults in roofs are: The oversailing of the purlin ends on hipped roofs without proper support. In fact in many roofs the purlins simply hang on the rafters and weaken the roof. The remedy is to strut the purlins from partition walls or beams, or to truss the timbers, and so reduce bending stresses.

Rot may be found in roofs. Torching tends to cause batten rot. Leakage may rot battens and rafters. Water leaking in may run down the underside of the roof and collect at the eaves, rotting fascia and soffit and the feet of the rafters. All rotten timber must be removed (see Chapter XII).

Birds in Roofs

Small birds can enter a roof through very small gaps. Such gaps are often found at the eaves where the feet of the rafters are open. Pointing up the beamfilling around the rafters will cure this trouble. Old verges may contain gaps. Every part of the roof should be searched for gaps, which should be made good.

Birds sometimes nest on the purlin projection under barge boards. The only way to stop this is to fix a barge soffit board.

SLATING

Natural slate is durable, and decay of slates rare. The weak spot is the fixing—the nails and battens. Corrosion of nails may leave the slate or battens loose. Battens rot in time, so that an old slated roof may be very loose, although the slates are as good as new.

Leakage in a roof which is sound is probably due to insufficient lap or pitch angle—though flashings may be defective.

Lap and Pitch

Lap and pitch should suit the position and relative exposure. For average positions the following are suitable:

<i>Pitch</i>	<i>Lap</i>
over 45 deg.	2½ in.
30 to 45 deg.	3 in.

A pitch of 30 degrees is a minimum for slates, though large slates have been used on lower pitches.

Slates should not be bedded or torched. They are liable to deteriorate if continually moist, and the laps and underside should have free ventilation. Nailing on battens without boarding or felting is best provided the pitch and lap are adequate. But in exceptionally exposed positions underfelting is essential if leakage is to be avoided.

If underfelt and boards are used, two improvements over common practice are recommended: First, to lay the felt vertically from ridge to eaves. Second, to fix the laths vertically. Any moisture penetrating the laps will then have a clear run down to the eaves gutter and felting and slates and battens are kept reasonably dry and well ventilated. With horizontal battens on boards the water collects on the upper edge of battens and may cause rot, unless vertical counter-battens are used.

In replacing rotten battens with new, it is advisable to treat the new ones with preservative.

Nails

Copper, composition, galvanised steel, and zinc nails are all suitable for slating and tiling, except under certain local atmospheric conditions.

Copper nails should not be used for large heavy slates, as they are rather soft and tend to draw. They are durable, except in an atmosphere heavily polluted with sulphur fumes.

Composition nails are harder and more resistant to corrosion than copper. Zinc nails are durable in a clean atmosphere, but in industrial districts rapidly corrode.

Removing Defective Slates

This must be done so as not to unduly disturb adjoining slates. The ripper tool, illustrated in Fig. 62, is used to cut the nails by slipping it under the lap and cutting the nails with the hooked blade. It may be necessary to use thin wedges to lift the adjoining slates.

A new slate is secured with a zinc or copper clip, as in Fig. 63.

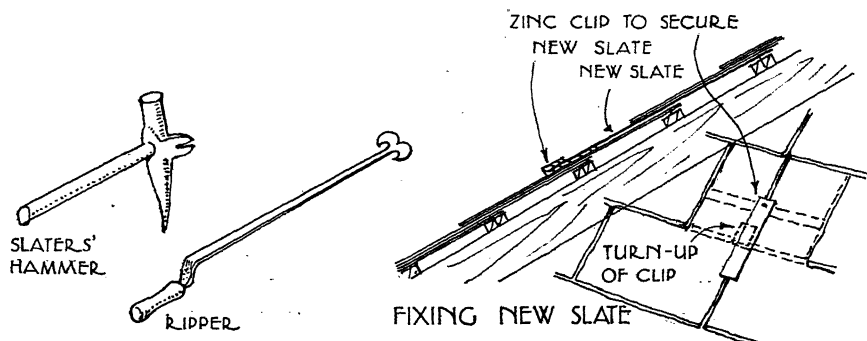


Fig. 62.—SLATER'S TOOLS

Fig. 63.—REPLACING SLATE

Another method is to secure a piece of triangular wood fillet across the middle of the slate with two lead rivets. The slate can then be pushed into position until the fillet "hooks" over the batten.

Roofs which are leaking badly are sometimes treated all over with a proprietary mastic. This seals the laps and holds the slates together, but this method should only be adopted when the money for a proper repair is not available.

ASBESTOS-CEMENT ROOF COVERINGS

These comprise slates, pantiles, corrugated sheets, large tiles which have corrugations with intervening flats, troughing and decking.

Asbestos-cement Slates

(Straight cover) are made in three sizes:

24 in. \times 12 in., 20 in. \times 10 in., and $15\frac{3}{4}$ in. \times $7\frac{7}{8}$ in.

Diagonal Cover (Diamond and Honeycomb) are $15\frac{3}{4}$ in. \times $15\frac{3}{4}$ in.

Colours: Natural grey, blue, red, russet-brown, and brindled. Also with mottled textures.

Asbestos-cement slates are fixed on ordinary battens, but rafters may be spaced up to 2 ft. 6 in. centres (considerable economy in timber results, as natural slates and tiles require a rafter spacing of 14 in.). The slates should be fixed with two galvanised nails $1\frac{1}{2}$ in. 11 B.W.G.

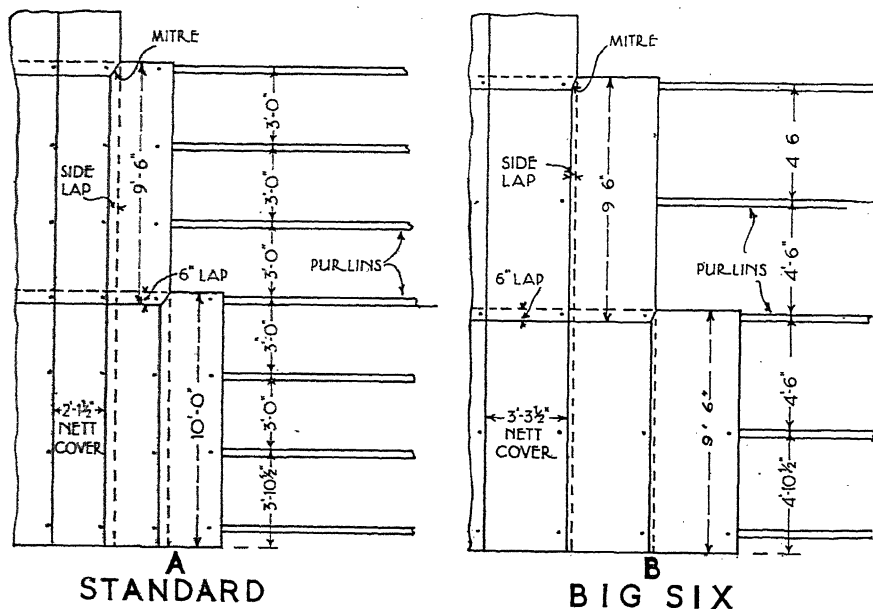


Fig. 64.—THE PURLIN SPACING FOR STANDARD CORRUGATED ASBESTOS SHEETS

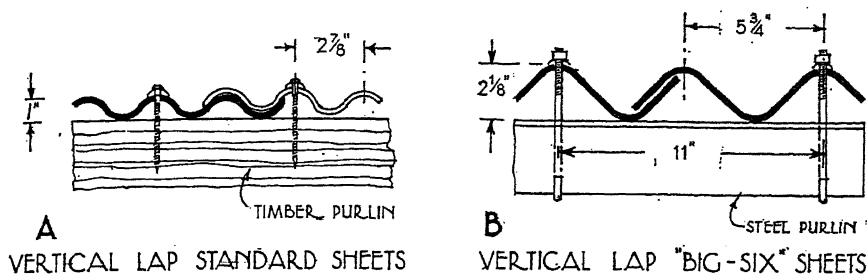


Fig. 65.—ASBESTOS-CEMENT CORRUGATED SHEETS

and a copper disc rivet. The rivet is fixed to hold the lower edge of the slate. Without this the wind would lift the slate owing to its light weight.

Asbestos-Cement Corrugated Sheets

This material is now widely used instead of corrugated iron, as it is proof against corrosion or decay, and does not need painting. Standard sheets are 3 ft. to 10 ft. long, rising by increments of 6 in. Width 2 ft. 6 in., with a nett covering width when laid of 2 ft. 1½ in.

Large corrugation sheets are made in the same lengths, but have a standard width of 41½ in.

The purlin spacing for standard sheets is 3 ft., as in Fig. 64 (A).

The purlin spacing for large sheets is 4 ft. 6 in., as in Fig. 64 (B).

Asbestos sheeting fixings are shown in Fig. 65:

The above gives only the briefest particulars of two asbestos-cement roof coverings. They are both useful for replacing old roof coverings and for extensions. Both are economical in roof timbers.

Roof ladders should be used when working on roofs covered with asbestos-cement sheeting. Years ago inferior sheets were sold which were weak, and accidents occasionally happen when a workman steps on to such a sheet, and it breaks. These inferior sheets deteriorate, but the reputable makes are durable and indeed improve with age.

If asbestos-cement sheets, of reputable make, crack it is due to faults in fixing. The material should not be rigidly fixed—the supporting structure must be free to move without imposing strain on the sheeting. Bolts or screws should not be fixed through side laps, but on each side of the lap, as in Fig. 65. Holes should be drilled, not punched, and should be 1/16th in. larger than the diameter of bolt or screw. Lead cupped and asbestos or felt washers should be used. The purlins must provide a straight bearing so that sheets are not strained by forcing them down.

Excessive deflection of weak roof framing may cause the sheets to crack.

Corrugated Iron

Galvanised corrugated iron is durable in a clean atmosphere, but in an acid-laden atmosphere the galvanising is attacked. It may be

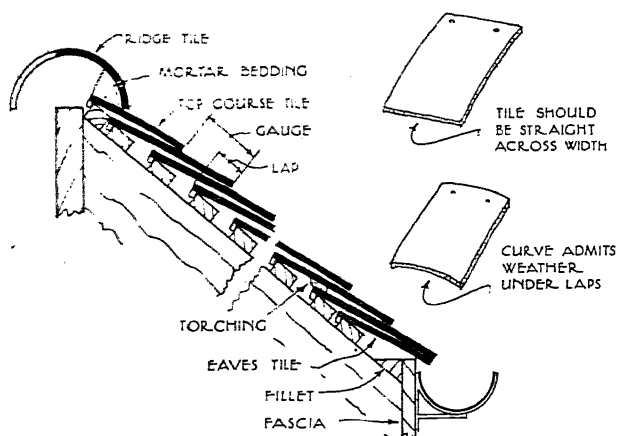


Fig. 66.—CLAY TILES (PLAIN TILING)

a sealed protective coating of a bituminous nature, durable in an industrial atmosphere. Any damage to the protective covering is easily repaired with bituminous mastics.

PLAIN CLAY TILES

Modern clay tiles (see Fig. 66), are usually reliable and durable, but older tiles vary greatly. An inferior tile may be affected by frost, and the whole roofing may suddenly crumble away. A durable clay tile must be well and evenly burnt, and of close texture.

The tile should be straight in its width, but slightly curved in its length, so that the lower edge evenly contacts the tile below, and the curve prevents water creeping up the lap by capillary movement.

Some tiles are curved across, as shown in Fig. 66. This allows water to be driven under the lap by wind.

Lap and Pitch

As with slates these should suit the position and relative exposure. For average positions the following are suitable:

Pitch	Lap
over 45 deg.	2½ in.
under 45 deg.	3 or 3½ ins.

For pitches less than 45 degrees underfelting is necessary, and underfelting should always be used in a roof exposed to gales. The flatter the pitch the greater should be the lap. The pitch should not be less than 35 degrees.

Torching

Torching is pointing between the tiles, underside. Though an old

protected with suitable paints (see Chapter XX). Any damage to the galvanising will be followed by corrosion which will work under the galvanising, forcing it off. So any damage to new sheets should be immediately painted.

Protected Metal

Sheets are now made which have

practice in many districts, it has disadvantages: First, that moisture soaks through it by capillary movement and reaches the battens and rafters, where it may cause rot; second, that in time it drops out, especially where there is much vibration from traffic, and also that frost may break up the tiles.

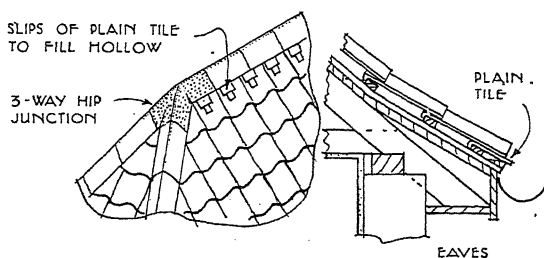


Fig. 67.—CLAY TILES (PANTILING)

The best method of making a watertight roof is to cover the rafters with boards and bituminous underfelt, and to fix laths to counter-battens.

The underfelt should be turned over the eaves gutter. By this method there is a clear space between counter-battens for any water which penetrates to run straight down to the eaves gutter.

Nails

This is described under Slates (page 109). It is usual to nail the two eaves courses, the ridge course, and every third or fourth course, using tiles with nibs.

On old roofs nibless tiles will be found, and they slip when the fixing gives way. Oak pegs or nails may be used for fixing nibless tiles. If a few nibless tiles slip on an old roof, it is almost certain that all the pegs or nails are giving way, and when a few tiles are disturbed the whole lot may start moving. It is better to remove and re-nail all of the tiles.

PANTILES

These single lap tiles with a trough section, $13\frac{1}{2}$ in. \times $9\frac{1}{2}$ in. \times $\frac{1}{2}$ in., should be laid as shown in Fig. 67. Ridges and hips have the troughs filled with courses of plain tiles. Eaves are filled with pieces of tile to close the roll. Verges and eaves have an undercloak of plain tiles.

In old pantiling the verges are not satisfactory owing to the absence of double roll tiles. Double roll tiles are now made for use on left-hand verges, and the effect is much better.

INTERLOCKING TILES

There are various proprietary designs. This is single lap tiling, and the weathertightness depends upon the locking design at head and side. The best makes are reliable, if properly laid. Defects sometimes arise through the use of distorted tiles, or careless laying, so that there is no effective interlock. Such tiling can be replaced only with tiles of the same type and make.

Faults in Clay Tiling

Some faults have already been mentioned. The chief faults are:

Distorted tiles, and hatched tiles (tiles with a cross curve).

Lamination.—Caused by faults of manufacture. The tile breaks into layers.

Underburning, or uneven burning.—Causing the tiles to crumble. Both lamination and crumbling are hastened by frost action.

BITUMINOUS FELT

The material consists of fibres impregnated and surfaced with bitumen. A fire-resisting felt is made incorporating asbestos fibres. Most manufacturers make four thicknesses: $\frac{1}{2}$, 1, 2, and 3 ply. The standard width is 36 in. in rolls of 24 yds.

For single-layer roofing the felt may be laid from verge to verge (horizontally), or from eaves to ridge (vertically). Laps should be 2 in. cemented together with the mastic provided by the felt manufacturers and nailed at 2 in. centres along the edges. The nail heads and edge of lap should be painted with a 2 in. band of mastic. Felt should be turned over eaves and nailed at 3 in. centres, painting over nail heads with mastic. Clout nails $\frac{7}{8}$ in. long, preferably galvanised, should be used. Allow 1 lb. nails to a square (100 sq. ft.) of roofing.

The roof boarding should be smooth. Upstanding edges should be planed down, and nail heads punched down. Edges of boards at eaves

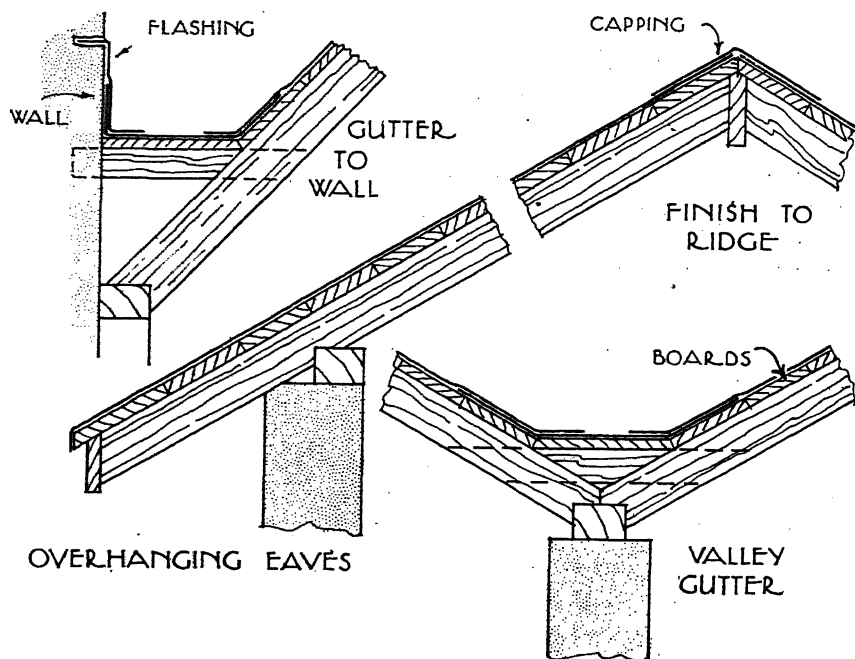


Fig. 68.—BITUMINOUS FELT ON TIMBER ROOF. SINGLE LAYER

should be rounded. Felt should be turned up parapet walls and chimneys against a triangular fillet. This avoids a sharp bend, which might damage the felt.

Flashings may be made in felt, but metal is preferable.

Wrinkling is a common fault. To avoid this, unroll the felt and expose it to the weather for a few days before fixing. The roof should be swept clean, and any knot holes covered with small pieces of felt or tin. Workmen should wear gum boots as boot nails may damage the felt.

In laying from eaves to ridge, do not carry the felt over the ridge. The felt on each side should finish at the ridge and be covered with a felt capping, cemented and nailed. Details, including gutters, are shown in Fig. 68.

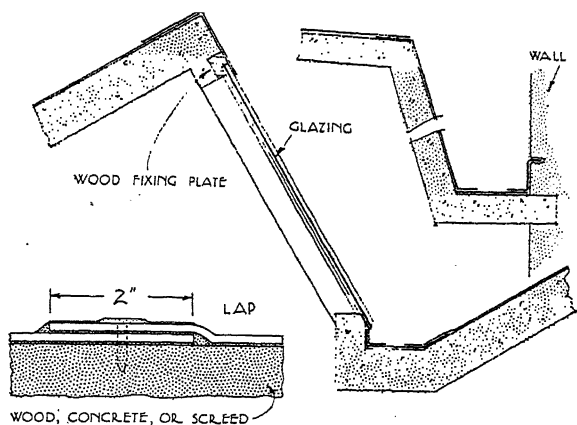


Fig. 69.—BITUMINOUS FELT ON CONCRETE ROOF.
SINGLE LAYER

Laying on Concrete

Felt must be cemented to concrete and cement surfaces with special mastic. Experience is necessary to make a satisfactory job, and most felt manufacturers prefer their own workmen to execute the work. Fig. 69 illustrates typical details.

Small cracks and leaks can be repaired with a bituminous mastic (see page 123). An old roof can be renovated by painting with a bituminous paint.

SHINGLES

Old shingled roofs are usually of oak or elm, though pine has also been used. Modern shingles are usually of Western red cedar, which is practically rot proof, and of moderate cost.

Shingles are nailed with galvanised or copper nails, flat headed, $1\frac{1}{8}$ in. long, 15 gauge. Each shingle is nailed twice, the nails passing through two shingles. The modern red cedar shingle is approximately 16 in. long, with widths of from 3 to 12 in. The best quality shingles are rift sawn (edge grain).

If an old shingle roof is badly decayed, it is advisable to strip and cover with Western red shingles.

THATCH

This is a country craftsman's job, and new thatch or extensive repairs are beyond the ordinary repairer, but owing to the lack of skilled craftsmen he may be compelled to attempt slight repairs. Rye and wheat straw should be used. Barley and oat straw rot quickly. The thatching is done by taking as much straw as can be gathered in both hands. This is called a yealm. The yealm is tied at the top to the roof rafters with tarred string. Avoid a butt joint—allow the yealms to overlap and mingle to make a weathertight joint. With a gable roof commence at the end of the eaves. With a hipped roof commence in the middle and work round the hips and valleys.

Along each side of the ridge bundles of straw should be laid horizontally and the yealms then laid saddleback and gently bent over. The eaves row should be of double thickness with a good overhang.

Hazel runners are used to secure the eaves, verges and ridges. The runners are about $\frac{3}{4}$ in. diameter, and 6 ft. long. They should be spiked to the thatch with hazel pegs bent hairpin shape, about 2 ft. long.

Trim eaves and verges with a long sharp knife.

When repairing remove a complete yealm, and replace with new straw, mingling the ends with the existing. Do not attempt to replace in very small areas.

Rats and birds may penetrate a thatched roof. To stop this, fix wire netting to the eaves and verges.

Fireproofing Thatch

The Society for the Protection of Ancient Buildings recommend the following treatments:

1. Whitewash the thatch when dry.
2. (For new thatch).—Before laying, soak for a day or two in the following solution—loading down the straw to keep immersed:
Alum $\frac{3}{4}$ lb.
Copper sulphate $\frac{3}{4}$ lb.
Water 50 galls.

Both treatments should be renewed at intervals of a few years.

Chapter XIV

FLAT ROOFS

FLAT roofs must have, of course, a fall for drainage. A desirable minimum is $1\frac{1}{2}$ in. in 10 ft.—though the materials and system should be taken into account.

Semi-flat roofs have a fall between about 4 and 12 degrees, which suits certain methods of construction. There is no sharp division, but it is convenient to regard roofs much over 10 degrees as pitched roofs.

The materials used for covering flat roofs are:

Sheet metals: Lead, zinc, and copper.

Bituminous felts: Single layer and built-up or multi-layer.

Asphalt: Screeded in situ.

Paved roofs: Tiles of concrete or asbestos-cement, in situ cement on bituminous felt or asphalt; macadam.

The materials used for covering semi-flat roofs are: As above for flat roofs, pavings excepted; and asbestos-cement troughed sheets, with special laps.

SHEET METALS

Lead, zinc and copper are laid by methods which allow for expansion and contraction and for slight movements of the roof structure. Properly laid, straining or rucking is avoided, but these faults are sometimes found.

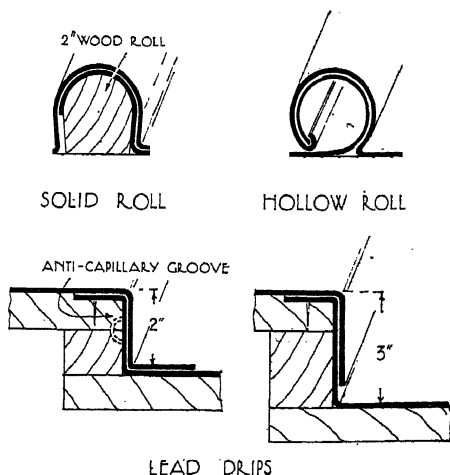
The sheets are not large, otherwise allowance for movement could not be made. The joints must be of a type which allow for movements without causing leakage.

Lead

Sheet lead may be cast or milled. Milled sheet lead is commonly used. Cast lead is more durable, though more costly.

For first-class work the lead should weigh at least 6 lbs. per foot super, and this weight is the minimum for hips, ridges and gutters. On cheaper work 4 lbs. lead is often used.

Solid and hollow rolls are illustrated in Fig. 70, and drips in Fig. 71.



LEAD DRIPS
Figs. 70 and 71.—LEAD ROLLS AND LEAD DRIPS

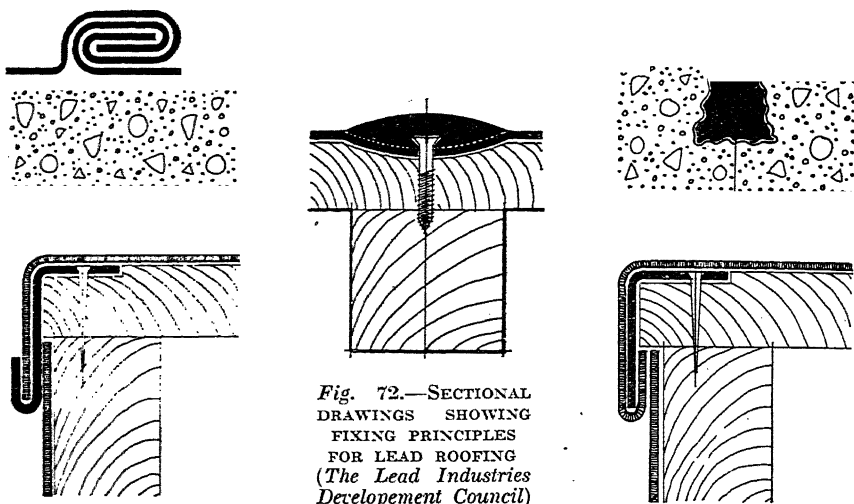


Fig. 72.—SECTIONAL
DRAWINGS SHOWING
FIXING PRINCIPLES
FOR LEAD ROOFING
(The Lead Industries
Development Council)

Fig. 72 illustrates fixing principles of a general character.

The solid roll with wood core should be used on roofs which are occasionally walked on. For example, a bay window roof, on which the window cleaners may walk to gain access to a flat casement above. Trouble is often caused on bay roofs through hollow rolls being damaged by window cleaners.

Drips are formed at right angles to the direction of fall for making joints in this direction, and to accelerate the flow of water. They should be spaced not more than 9 ft. apart. A drip should be 3 in. deep, though it may be less if a groove is formed in the upstand of the roof to prevent water rising through the lap by capillary movement.

Gutters, valleys, hips, ridges and flashings can also be formed in lead.

Zinc

Only the best zinc should be used for roofing. The best is of uniform quality and colour. Inferior zinc has patches of slightly darker tone which are liable to decay.

Zinc should not make contact with copper or iron. Such contact causes electrolytic action. In the presence of moisture contaminated with acid (such contamination is especially heavy in industrial and urban areas), an electric current is generated by the same action as the Leclanche cell and the common dry battery. This is accompanied by chemical action which eats away the metals.

Zinc should not be placed in contact with lime or lime mortar, as this also sets up chemical action which destroys the metal.

The laying and jointing of zinc differs from that of lead as zinc is not so easily worked into shape. Zinc must be bent before fixing. A zinc

roll should be formed with a wood core, as in Fig. 73. In cheap work a plain soldered seam is made, and a hollow roll is soldered on that. The rolls are useless, and a few knocks will break them off. It will be noticed in Fig. 73 that the proper roll has no soldered seam, and the metal can ex-

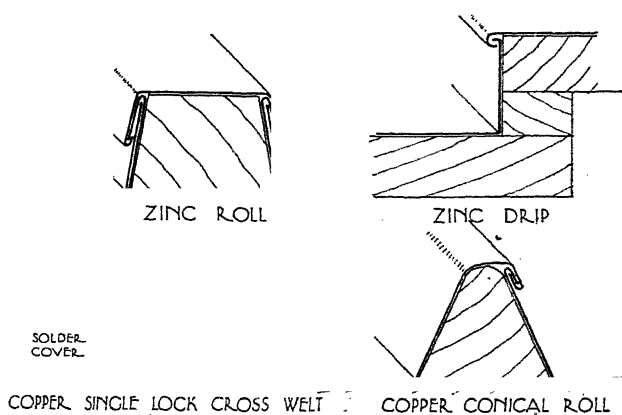


Fig. 73 and 74.—ZINC AND COPPER ROOFING

and the metal can expand and contract without straining the joint. A zinc drip joint is shown in Fig. 73. Notice the difference from the lead drip.

Copper

This metal is extensively used for both flat and pitched roofs. It is usually fixed by specialist firms, though there is no reason why the plumber should not undertake the work, provided the principles of working the sheet metal are understood. Modern copper roofing is a big subject. The Copper Development Association issue comprehensive technical publications on the subject.

The expansion and contraction movement of copper is considerable, and it is important to allow for this. The boarding should be covered with underfelt or building paper. The weight of copper used for roofing is 24 S. W. gauge, weighing 16 oz. per ft. super. For extra strength and wear the heavier 23 gauge (19 oz.) is used. Sheets for roofing are commonly 8 ft. × 3 ft.—though larger sheets are obtainable.

Joints for copper roofing are illustrated in Fig. 74. The single lock cross welt can be covered with solder, as shown. This is a good repair for leaky welts.

REPAIR OF METAL ROOFINGS

The faults commonly met with are: Wear caused by the flat being used by window cleaners and others. Fine short cracks due to thermal movements. Long cracks due to the same cause. Small punctures due to damage or to some projection from the boarding, such as a nail head. Wrinkling due to thermal movement of the metal or sagging of the roof structure.

Worn or badly defective patches of lead should be cut out, and a new piece carefully fitted. The edges should be flattened down with a dresser. A margin at least $\frac{3}{4}$ in. wide on each side should then be scraped

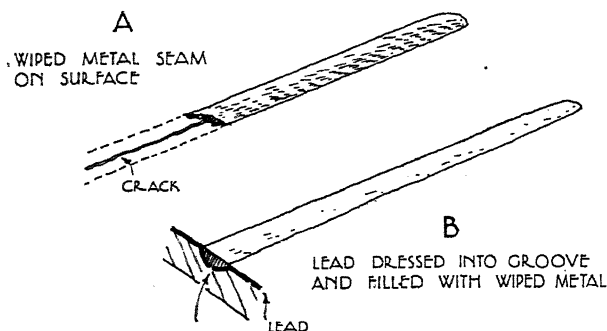


Fig. 75.—WIPED LEAD SEAM REPAIRS TO LEAD ROOFS AND GUTTERS

clean all round the patch. After preparation, a seam of molten metal should be wiped along the prepared margin, as in Fig. 75 (A).

If the roof has a good fall, and a wiped seam (across the direction of fall) is not too thick, the water will be able to drain over the seam. But if the fall is

slight, the lower edge of the patch should be worked into a semi-circular groove cut in the boarding, so that the wiped seam just fills the hollow after the lead has been dressed into it, as in Fig. 75 (A).

Fine cracks are caused in lead by thermal movements (expansion and contraction). If there is a leakage, and the lead is wrinkled, fine cracks may be formed along some of the wrinkles. The wrinkles should be flattened with the dresser, and a margin scraped clean along the cracks. A wiped seam is then run over the crack.

If the crack is across the direction of fall, and is very long, the wiped seam standing above the surface would impede the drainage of the roof. In such a case a semi-circular groove should be cut in the roof boarding and the lead dressed into it so that a flush seam can be wiped, as already described and illustrated in Fig. 75 (B).

The above method can also be used for repairing lead gutters and valleys.

Small spot defects in lead can be repaired by punching the metal down to form a hollow depression in the boarding and wiping over the depression with a flush surface. Nail heads often work up in old roofs and cause these spot defects. By punching as described the nail head can be driven down and the hollow formed at one operation.

Wrinkling is common on old lead roofs, and, as already stated, leads to cracking. When making repairs all wrinkles should be dressed flat.

Lead should not be nailed, but the repairer may find roof lead which has been improperly fixed in this way.

Zinc and copper may develop fine cracks or spot defects, though, if free to expand and contract and not subjected to rough usage, such defects are rare. The simplest cure is to clean, flux and solder the defect, though a badly damaged portion should be cut out and a new piece fitted.

Flashings

Where metal roof coverings meet a wall or chimney they should be turned up about 6 in. A metal flashing should be fixed into the wall

about 1½ in. and a lead flashing should be wedged with lead wedges and then pointed in cement mortar. Chimney flashings have already been illustrated in Fig. 46. Flashings should lap 4 in.

Zinc and copper flashings are designed on the same lines, though it is desirable to fix a wood fillet against the wall so that the roof sheeting need not be bent to a sharp 90 deg. angle.

ASPHALT

This well-known roofing material is durable and impervious. It retains some elasticity. It is applied hot, and floated to a smooth surface. The work can be successfully undertaken only by specialist firms. Asphalt roofing is easily repaired, as defective patches can be cut out and refilled, the new asphalt bonding well to the old. All but the smallest repairs should be carried out by a specialist firm. Small defects can be repaired by treating with a cold bituminous mastic (see page 123).

Felt Underlay

This is recommended for concrete roofs. It allows freedom of movement by preventing the asphalt adhering to the concrete. Any shrinkage cracks developing in the concrete will not then affect the asphalt.

As the asphalt does not adhere to the roof it is important to key it to parapets, curbs and eaves. It should be turned into grooves in parapet walls and chimneys, and grooves should be made in the edge of the concrete flat, where the asphalt is turned over the edge. On timber roofs expanded metal should be fixed to eaves to provide a key.

All asphalt skirtings and upstands should have an asphalt triangular fillet in the angle.

Asphalt is used in conjunction with an underlay of one or two layers of bituminous felt cemented together with hot bitumen in certain proprietary forms of roofing. This roofing has extra ductility, and so allows considerable movement of the supporting structure without ill effects on the roof covering.

Faults in Asphalt

As the success of asphalt roofing largely depends on the workmen who lay it, any careless workmanship may leave weaknesses. Faults sometimes develop where the work of one day was joined to that of the previous day. But all leakage faults can be easily repaired by the specialist workmen.

If a roof covered with ordinary mastic asphalt is much used for walking or other traffic, the asphalt will wear rather rapidly, and may be damaged. For traffic use, a hard grade of asphalt ⅝ in. thick is laid over a ⅔ in. thickness of ordinary asphalt. Any asphalt roof which is badly worn through such use, should therefore have a top layer of hard asphalt added.

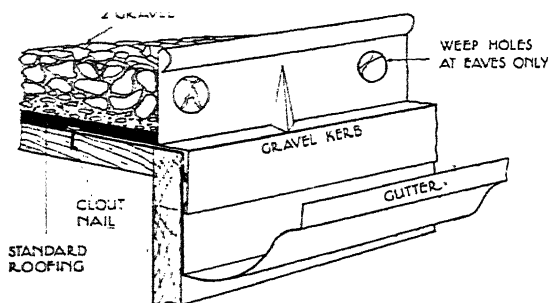


Fig. 76.—SECTION SHOWING GUTTER FIXED TO FASCIA AND EAVES KERB IN POSITION

with a bituminous compound and spreading 2 in. of gravel, or sand and gravel, over it. Precautions should be taken to prevent loose gravel choking gutters and rainwater down pipes. Sweep off any loose material, and cover the gutter outlets with a wire rose. A zinc or copper gravel curb should be fixed at the eaves, as in Fig. 76. The holes allow for drainage.

Mastic asphalt laid on underfelting gives a good wearing surface for foot traffic. Macadam can be used instead of asphalt. There are several proprietary systems of roof paving applied to bituminous underfelting. Cement and concrete tiles, and asbestos-cement tiles jointed in bituminous mastic are the usual pavings. Special tiles for thermal insulation are also made.

These proprietary roofings are laid by the maker's workmen, and should be repaired by them. Shrinkage leaks, if slight, may be made good with a suitable bituminous mastic.

SEMI-FLAT ROOFS

These roofs have a fall ranging between 4 and 12 degrees. Any of the materials above described can be used. The extra fall makes for good drainage.

There are also systems of roofing with laps which are water-tight only against water running over them, and so require a fall of 4 to 12 degrees. There is one such system

FLAT ROOF PAVINGS

Metal and bituminous felt roofings are not suitable for continual foot traffic. They will stand the occasional traffic of window cleaners and workmen, but for continual traffic a hard-wearing surface is required.

An existing single layer felt roof, if of good quality felt, can be surfaced for light foot traffic by coating

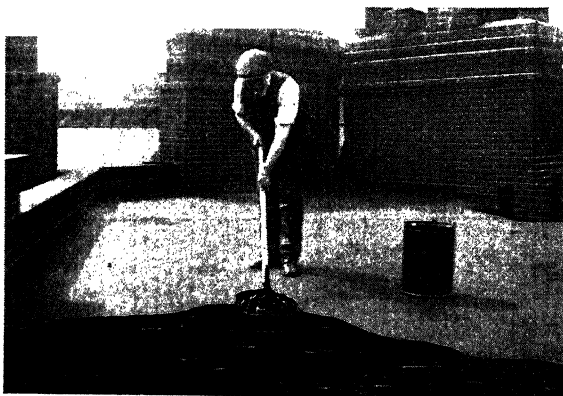


Fig. 77A.—FELT ROOFING BEING RENOVATED
"MOPPON" BLACK COMPOUND

employing asbestos-cement troughed sheets with the top edge turned up and the bottom edge turned down. Such systems are economical for wide spans employing lattice or other trusses of low pitch. They are, of course, unsuitable for foot traffic.

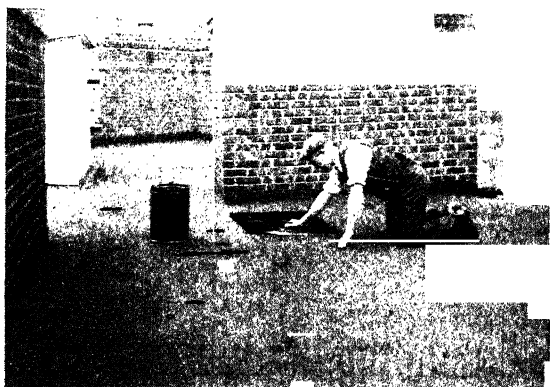


Fig. 77B.—REPAIRING CRACKS IN ASPHALT ROOF WITH “PLASTALEKE” (George M. Callender & Co., Ltd.)

Roof Repairing Compounds

Bituminous paints may be used for preserving or renovating felt and corrugated iron roofs.

There are a number of proprietary mastic compounds for repairing leaks and cracks in roofings. These mastics incorporate asbestos. They retain a certain amount of elasticity, and are not affected by water, heat, or frost. They adhere very tenaciously to any kind of surface.

They can be applied with a trowel for repairing cracks in all roofing materials on flat and pitched roofs.

Fig. 77A shows a felt roof being renovated with “Moppon.” Fig. 77B shows cracks in an asphalt roof being repaired with “Plastaleke.”

Cement and cement slurry cannot be relied upon for roof repairs, though they are sometimes used on old tile roofs to make a cheap repair.

Chapter XV

SOUND AND THERMAL INSULATION

FAULTS arising from inadequate insulation are of two distinct kinds:

- (1) Noise generation and transmission.
- (2) Heat transmission, resulting in rooms being very hot in summer and rapidly losing heat in winter.

Although the two problems are often connected, the causes are not necessarily the same.

NOISE

A background of noise maintained at one level is not usually objectionable—provided it is not of excessive volume.

Intermittent noise is irritating: the backfiring of a car engine, and footsteps on a hard floor, to give two examples.

Sources

There are three sources:

- (a) Internal noises generated within the building.
- (b) Noises transmitted from adjoining premises.
- (c) Street and other external noises.

Internal noise is best tackled at the source. In most cases it is easier and cheaper to prevent the noise being generated (or to greatly reduce it) than to prevent it being transmitted through the building.

Soundproof construction is rarely practicable, and in any case is costly, whereas quite simple measures will greatly reduce noise generation. Measures for reducing sound transmission in a new building should certainly be taken, but they are costly to apply to an existing building.

Noise and Planning

It is advisable to have a room in which quiet is desired placed as far as possible from a noise source. By careful planning this can be done in a new building, but it is also often possible to re-arrange the functions of the various rooms in an existing building to reduce noise nuisance.

For example, in an industrial building the offices may be in a separate building connected to the factory by short corridors. An alternative is to arrange store rooms, lavatories, and rooms for light processes between the main factory and the offices. Store rooms, etc., can also be placed between the main office and private offices. In an existing building this may be easily arranged by partitioning off a portion of the main office for use as a store.

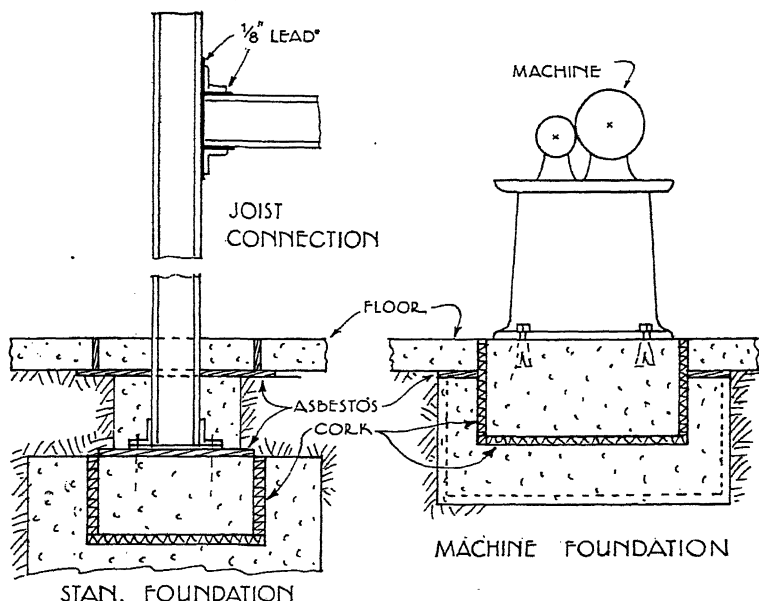


Fig. 78.—INSULATING STANCHIONS AND BEAMS

Fig. 79.—INSULATING MACHINE FOUNDATIONS

In a multi-floor building store rooms can be arranged on one floor to separate a lower floor containing machinery from a higher floor containing offices.

In a house, if the hall, cloakroom, etc., are arranged at the front, the living rooms will be protected from street noises to a large extent.

Reducing Noise at Source

Impact noises caused by walking on hard floors can be cured or greatly reduced by covering the floors with a resilient material, such as rubber, carpets, mats.

Noise is readily transmitted through structural framework. To reduce this transmission foundations and connections should be insulated, as in Fig. 78.

Noises from machinery are transmitted through the floors and walls of the building. In some cases attention to the noisy parts of the machine will reduce the noise generation. Belts, bearings and gears generate noise if they are worn or loose.

Sound insulating foundations should be provided to prevent the noise vibrations being transmitted to the main structure. Typical details are shown in Fig. 79. Sheet lead, asbestos, and cork, and thick fibre board can be used for this purpose.

Noise from a W.C. is transmitted mainly through the soil pipe which

is difficult to insulate, but if a "silent" flush low-level cistern is installed, noise should not be excessive.

Insulating the Structure

Sound is transmitted through a building in two ways: by passing directly through floors, ceilings, and walls; and by passing along the structural parts, especially by transmission along framing members such as stanchions, beams and floors.

Thin sheeting acts as a diaphragm—vibrating in sympathy with the sound waves and transmitting and reproducing the sound waves on the opposite side or in some other part of the structure. Boarded floors and plastered and sheeted ceilings act as diaphragms, and also glass windows and sheeted partitions.

The sound-absorbing properties of a floor or wall can be improved by adding to the thickness, using such materials as thick fibre board, cork, and sound-absorbing quilting. But the common practice of adding a single sheet of thin fibre board does not result in much improvement.

Sound Absorption

The following methods of treatment will improve the sound absorption of walls and partitions:

Pumice concrete or breeze concrete partition blocks 3 in. thick, built on layer of cork or asbestos fibre, the blocks being plastered on the exposed face. If the blocks are built separate from the wall, with an air gap of about 2 in., the insulation will be better.

Thick fibre or plaster board, at least $\frac{1}{2}$ in. thick, nailed to wood battens, sound-absorbing quilt being placed between the fibre and battens.

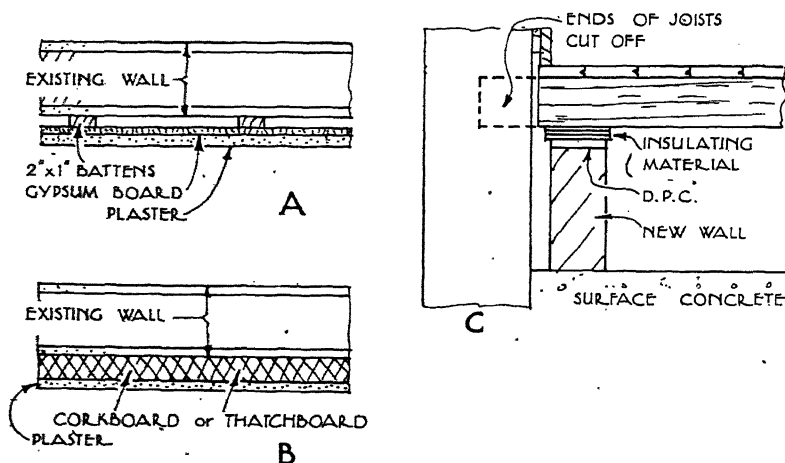


Fig. 80.—(a and b) INSULATION MATERIAL ADDED TO WALLS. (c) INSULATING FLOOR JOISTS FROM WALL

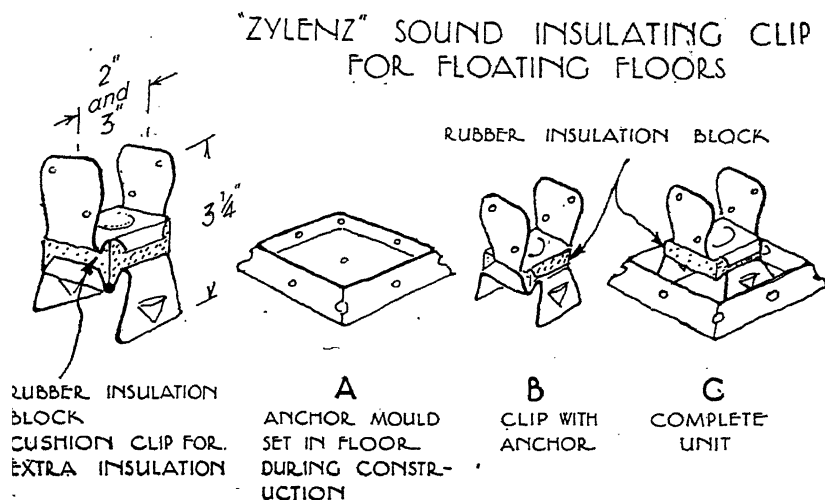


Fig. 81.—INSULATING CLIPS FOR FIXING BATTENS

A separate partition built clear of the wall and insulated by a cork or asbestos fibre foundation. Hollow clay, concrete, or plaster blocks are suitable, or a timber framed partition faced with thick fibre board.

Fig. 80 illustrates a few methods of improving sound insulation.

In a new structure the connections between the walls and floors, and any framing connections, should be insulated. Unfortunately it is almost impracticable to use these methods in an existing building.

As boarded floors with the joists built into the walls readily transmit sound, it may be worth while in a bad case to build a separate sleeper wall, or fix a beam, to support the floor joists, afterwards cutting off the ends of the joists. The joists should have thick insulating material placed under the bearings, as shown in Fig. 80 (c).

It should be realised that at least as much noise is transmitted through boarded floors from one room to another as through the wall separating those rooms. It follows that improving the sound absorption of the wall will not necessarily cure the trouble.

Boarded floors on concrete should have the battens fixed to insulating clips as in Fig. 81.

Windows

Windows admit street noises. The replacement of thin sheet glass with thick plate glass will effect some improvement. Double windows glazed with plate glass are better, but such a remedy is costly.

Acoustics

The acoustics of big halls, churches, concert halls, etc., is a specialist subject which it is impossible to treat here in detail.

It is well known that echoes are caused by the reflection of sound from hard surfaces. The shape of the building and the furnishing also affects this problem. The cure is to provide sound-absorbing surfaces. Special materials such as fibre board and thatchboard of low density are used for this purpose, and also special sound absorbent tiles.

Soundboards of a thick hard material, specially shaped to direct the sound in the desired direction, are used where the problem is to make a speaker's voice heard throughout a large hall.

The repairer should not undertake the cure of any but very simple problems without expert advice.

THERMAL INSULATION

This is insulation against heat and cold. The object is to prevent the rapid transmission of a change of temperature from the outside of the building to the inside. An important aspect of thermal insulation is to prevent heat losses from a building during cold weather, and conversely, to prevent the interior becoming uncomfortably hot during hot weather.

The fuel economy resulting from a high degree of thermal insulation is considerable.

The average house is satisfactory from this point of view, except in the matter of heat loss due to draughty doors and windows. A house in an exposed position will greatly benefit from measures designed to close the small gaps commonly found around doors and windows, though it must be remembered that a certain amount of air is required for ventilation and the proper combustion of solid fuels.

Outer walls of brickwork, concrete, or masonry, at least 9 in. thick with the interior face plastered have fairly good thermal insulation. Thin partitions have low insulation.

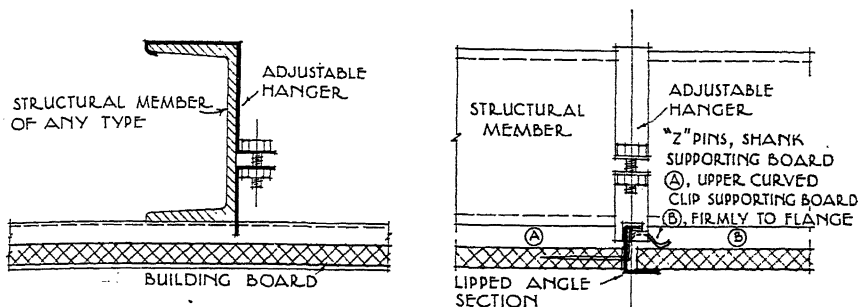
The pitched roof of the average house, with slate or tile covering and plastered ceilings, has good thermal insulation, though it is much better, if the roof is boarded. Underfelting also improves the insulation, not so much by its own insulation value as by preventing draughts through the laps of the slates or tiles.

Flat roofs are sometimes deficient in thermal insulation. A wood joist roof covered with bituminous felting on boards, and with a plastered or sheeted ceiling, is not satisfactory in very cold weather. The insulation can be greatly improved by adding thick fibre or thatch board, or cork-board. A thickness of at least 1 in. is essential for any real improvement.

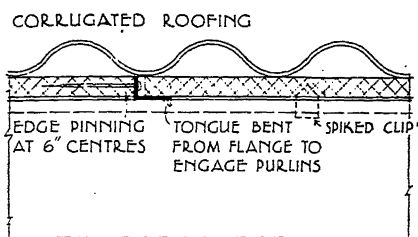
Factory buildings have often very low thermal insulation, and heat losses in cold weather are consequently very great.

If the building is steel or reinforced concrete framed, the panel walls may be thin—in some cases consisting of corrugated sheeting with no lining. An open roof covered with corrugated sheeting or bituminous felt on boards has low thermal insulation.

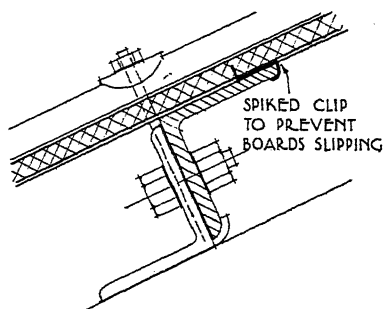
For such buildings a considerable scheme must be adopted to effect any real improvement. Sheeted walls of framed buildings can be lined



METHOD OF FIXING UNDER PURLINS OR STRUCTURAL MEMBERS



SECTION AT RIGHT ANGLES TO ROOF SLOPE



METHOD OF FIXING OVER PURLINS

Fig. 82.—FIXING INSULATING BOARD TO WALLS AND ROOFS WITH PATENT STEEL ANGLES AND CLIPS (*Pimco System*)

with thick fibre board, though it may be necessary to have a stronger lining for the first five or six feet from the floor.

Pressed steel flanged laths or battens with clip fixings are made for fixing flat sheetings to walls, ceilings and roofs. There are several proprietary systems, one of which is illustrated in Fig. 82. The accessories supplied with these products enable fixings to be made to any material in any position. The work can be rapidly executed.

Where ceilings are added to open roofs, care must be taken to provide extra structural support unless the existing trusses are strong enough to take the extra load.

Heat losses through open doors and windows in large factories and halls may be considerable. While adequate ventilation is essential, in many cases there are more openings than are necessary in cold weather.

It will be realised that many of the methods and materials recommended for sound insulation also improve thermal insulation. The two problems should be considered side by side.

Chapter XVI

SANITATION AND DRAINAGE

MODERN improvements in sanitary fittings have been especially directed to easy cleaning, labour saving, and reliability. The cheapest equipment is still liable to develop defects which prove to be incurable. Much time and money can be spent on making temporary repairs to old fittings. It is much more satisfactory, and cheaper in the long run, to replace with modern fittings of good quality. Even if old fittings work properly, it may pay to replace with modern fittings which are labour saving. Chromium plated and stainless metal taps of the "easy-clean" shapes provide a good example. Where extensive re-fitting of a building is undertaken, all old brass taps should be replaced with modern stainless easy-clean fittings.

SANITARY FITTINGS

Baths

Baths are easier to keep clean and better looking if fitted with enclosed sides and ends. The best and most costly type is cast in one piece—sides and ends being in one piece with the bath—and porcelain enamelled inside and out. Others have separate sheeted sides and ends, the sheeting materials being marble, decorated asbestos-cement, opaque coloured glass, and enamelled steel. A tiled bath enclosure can be formed on a rendered expanded metal base. A better, but unusual position for the bath is to place the end *without* fittings and waste against the wall. This enables the end with fittings and waste to be readily accessible by simply removing the end panel of the enclosure. Every plumber knows how awkward it is to get at pipes and connections jammed a few inches between bath and wall.

Lavatory Basins

The best modern types of lavatory basins have splash backs and recessed soap holders, the latter being separate fittings built into the wall. The pedestal type basin enables pipes to be concealed.

W.C.'s and Cisterns

The best types are obtainable in white glaze and a range of colours. Seat is of one-piece moulded plastic material which is non-absorbent and highly polished.

Fig. 83 illustrates a cistern designed for practically silent flushing.

Cisterns should have a silencing tube on the inlet, as in Fig. 83. This prevents noise from the splash of water as the cistern fills. It is an easy

matter to fit a metal or rubber tube to an existing inlet valve, though this tube cannot be fitted to the Croydon type valve.

The noise of discharge when the W.C. is flushed can be greatly reduced by fitting a low-level cistern specially designed for noiseless operation, or by fitting a flushing valve instead of a cistern. The flushing valve must have a large diameter supply pipe, from 1 in. for a water pressure of 25 lb. per sq. in. to $1\frac{1}{2}$ in. for 15 lb. pressure.

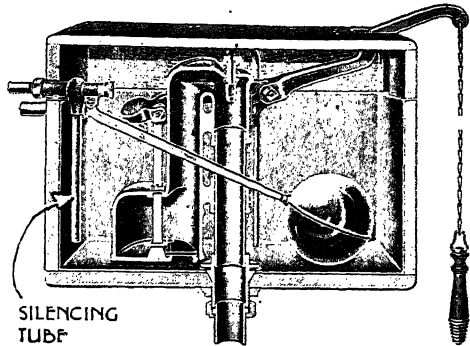


Fig. 83.—SECTION THROUGH NOISELESS FLUSHING CISTERN (Clark Hunt & Co., Ltd.)

Imperfect functioning of the inlet valve in flushing cisterns is a common fault, the valve failing to close properly when the cistern is full. Wear of the valve contact faces and washer is sometimes the cause, and sometimes there is too much free play on the moving parts. Grit in the water may occasionally stick in the valve and prevent it closing. The fault is particularly common in the cheaper cisterns. It is better to fit a new valve of good quality than to make repeated adjustments.

The Croydon valve will usually be found in old cisterns. The Portsmouth is a better type—the Equilibrium another.

Sinks

All sinks should be reasonably deep as shallow sinks allow water to splash over the edge. The deep "Belfast" is a good type. Draining-boards of asbestos-cement are better than wood (with the exception of teak). Stainless steel sinks and draining-boards in one unit are best, but are expensive.

PIPES AND JOINTS

For water supply copper is preferable to lead where the pipes are exposed, as it is easier to clean, and patent expanding joints can be used.

The old type connection between flush pipes and w.c. pedestal consists of putty and tape. It always develops faults. The rubber cone joint is now widely used—it is an efficient, durable, and easily made joint.

Traps

Traps for sink, lavatory basin, and bath waste are more easily connected if of a patent type allowing connections to be made without the use of solder.

Syphonage in waste traps can be cured without the use of anti-syphonage pipes by fitting one of the patent traps designed to resist

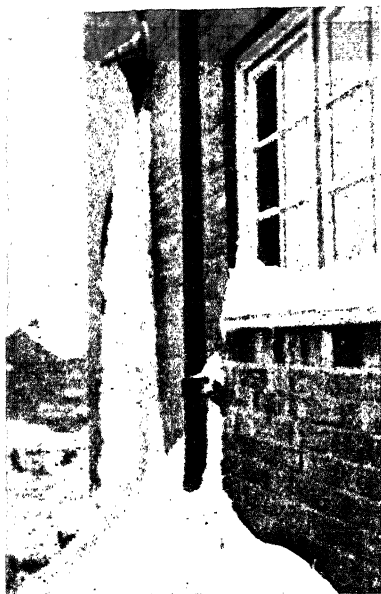


Fig. 84.—ICE ON PIPE DUE TO DRIP THROUGH WASTE OUTLET

unsealing. The McAlpine and the Greenwood Anti-Vak are two well known makes.

PROTECTION AGAINST FROST

Water expands when it freezes. The pressure may burst the pipe, though the burst will not be apparent until the ice melts. In Britain a spell of severe winter weather with temperatures well below freezing causes extensive damage to pipes owing to lack of thermal insulation. Water pipes fixed inside the building to outer walls should be protected by wrapping with an asbestos or other insulating material and casing in wood—the casing to be fixed with brass screws and cups, so as to be removable. Water pipes and open tanks in the roof should also be cased with insulating material, and should have wood covers, lead or zinc lined.

Water pipes underground should have at least 2 ft. of earth cover.

Waste and overflow pipes projecting outside should be protected. A leaky tap discharges water through the waste pipe, and in frosty weather this may produce the result illustrated in Fig. 84. Temporary protection should be given to waste water pipes and heads by covering with straw, sacking, or other suitable material. Outside stop-cock boxes should also be protected.

Where outside waste and soil pipes are in an exceptionally exposed position, and freezing occurs each winter, it is advisable to wrap the pipes with an asbestos fibre insulating fabric.

SOIL PIPES

These are usually of cast-iron, though lead and copper are also used.

Cast-iron soil pipes may be fixed inside the building if coated inside and out with Dr. Angus Smith's solution. With the pipes inside damage by impact is prevented, expansion and contraction is less, resulting in longer life for the joints, and freezing of the water in the w.c. trap is less likely.

Soil pipes should be not less than 3 in. diameter, and should be continued upwards above the eaves (so that the top is at least 3 ft. above the top of the nearest window) to ventilate the drains to the open air. The top must be protected from birds. This is usually done by fixing a wire ball, but a cast-iron cowl is much better and more durable.

Joints in cast-iron soil pipes should be made by placing a gasket in the bottom of the socket and then filling with molten lead, afterwards caulking the lead to make the joint tight, as in Fig. 85 (A). The lead should entirely fill the joint when caulked. Any depression left will fill with water which may cause trouble during frost.

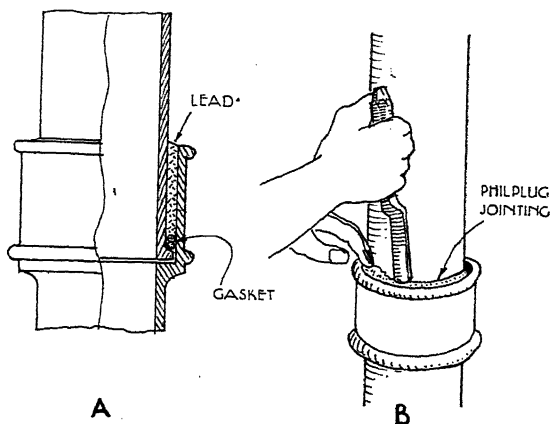


Fig. 85.—JOINTS IN CAST IRON SOIL PIPES

Proprietary jointing compounds may be used instead of lead, as in

Fig. 85 (B). Lead soil pipes have a smoother interior than iron, but are more costly. Copper is now often used in high-class work. With both copper and lead, joints to make up lengths are not required.

Faults in Soil Pipes

With cast-iron pipes, the joints may become loose owing to the unequal expansion of iron and lead. Re-caulking will usually cure the trouble, though extra lead may have to be added to fill the joint.

Fractured cast-iron pipes should be replaced. The standard length is 6 ft.

Fractures in lead soil pipes can be wiped. A badly buckled lead pipe must be cut out. In old buildings, soil pipes of sheet lead with a soldered seam may be found. These seams develop leaks. While they are easily repaired by re-soldering, it is better to remove such pipes and replace with drawn lead or cast-iron pipes.

Joint between Soil Pipe and Drain

With a cast-iron soil pipe, the spigot of the iron pipe stands in the socket of the stoneware drain pipe. A hemp gasket is then placed in the bottom of the joint and well caulked. The joint is completed by filling with Portland cement mix (1 cement to 1 sand), packing it well in and sloping the top outwards.

A joint between a lead soil pipe and a stoneware drain is made by fixing a brass thimble at the bottom of the lead pipe with a wiped joint. This supports the end of the pipe. The joint is then caulked with a hemp gasket and filled with cement, as described for an iron pipe.

Where bad smells are found, soil pipe joints should be examined first, and any looseness or shrinkage attended to. If necessary, make a new joint. Don't use dabs of putty or cement to stop a leak.

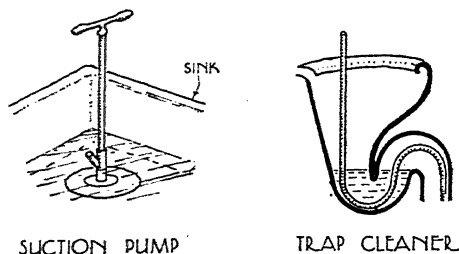


Fig. 86.—TRAP CLEARANCE

wire or a coiled spring round the bend. Fig. 86 shows how a suction pump can be used to clear a sink trap. Also shown in Fig. 86 is a flexible cleaner for rodding a w.c. trap.

Objectionable smells sometimes rise from waste pipes. This is due to the soap and dirt adhering to the inside surface. To cleanse the pipe, plug the outlet and fill with hot soda water. Leave this for some hours and then empty. Repeat the treatment a few times, and then flush with a disinfectant.

Drainage

Drains may take the sewage and rainwater into one drain, or there may be separate drains connected to separate sewers. Where there are separate foul and surface water drains, many local authorities allow half the roof surface water to be discharged into the foul drain. In repair work it is essential to find out what system is used, and if it is still the system approved by the local authority. Any extensions will be subject to the latest by-laws and the approval of the local sanitary inspector or surveyor.

A typical single drain system for a small house is illustrated in Fig. 87 (A). A typical double drain system for the same type of house is illustrated in Fig. 87 (B).

Fig. 87(c) shows how the drains are ventilated.

In porous subsoil, the roof surface water is sometimes discharged into sumps or soak-aways.

WASTE TRAPS

Waste pipes from lavatory basins and baths are of lead or copper. They should be trapped, and the trap should have a brass cleaning eye at the bottom. This enables any stoppage to be easily cleared.

A stoppage in a trap not fitted with a cleaning eye may be cleared by pushing thick

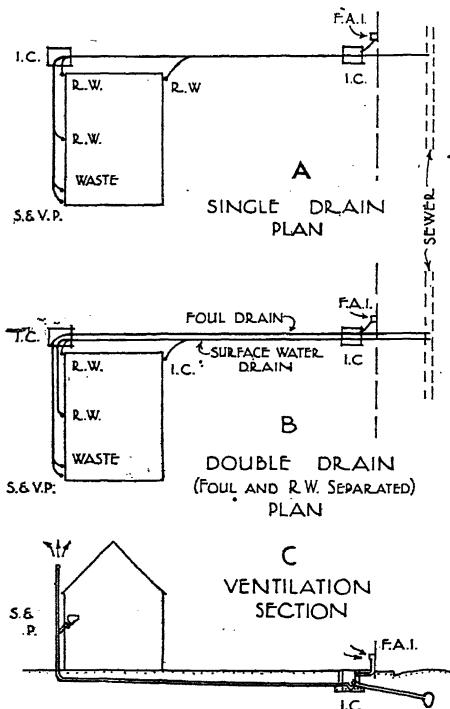


Fig. 87.—THE DRAINAGE OF BUILDINGS

These sumps may consist of small pits filled with rubble or stones, or brick-lined chambers with weep holes, surrounded on the outside with small stones. It would, of course, be useless to expect sumps to function in an impervious clay subsoil.

Rainwater sumps may silt up and become choked. The drains then fill with water until the water may burst through a joint—generally in the iron r.w. down-pipe. The only remedy is to clean out the sump. This is obviously easier in the case of a brick-lined sump.

Rainwater can also be discharged into ditches and streams. Care must be taken that flood water cannot rise up the drain. This can be prevented by fitting a flap valve on the outlet, or an anti-flooding bay valve.

Drain Pipes and Bends

These may be of glazed earthenware or of cast iron.

Glazed Earthenware

(Stoneware) pipes are made in 2 ft. and 3 ft. lengths, with socket and spigot ends. The most common joint is made with Portland cement. Tarred gaskin or hemp should first be caulked into the joint to prevent the cement leaking into the pipe. Then mix a stiff mortar of 1 part cement to 1 or 2 parts clean sand. Pack this well into the joint and finish it to cover the end of the socket, as shown in Fig. 88 (A).

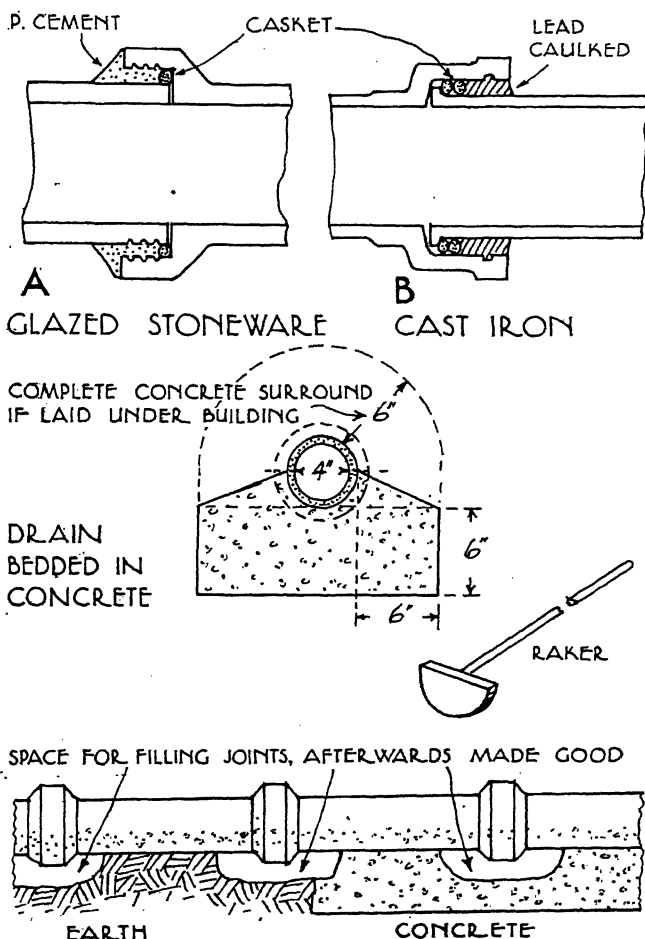


Fig. 88.—JOINTING DRAIN PIPES

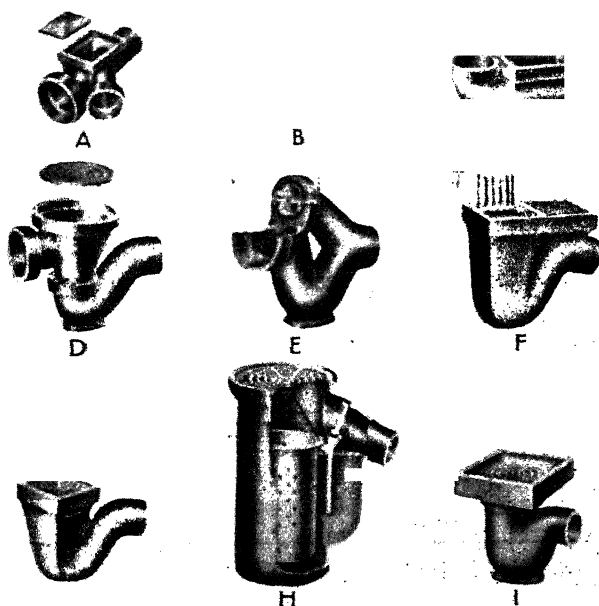


Fig. 89.—GLAZED STONEWARE DRAIN PIPES AND FITTINGS
(Doulton & Co., Ltd.)

In making joints, a space must be cleared under the socket to allow the jointing material to be packed into the socket space. When pipes are laid direct on the ground the soil should be excavated for a few inches under the socket. If laid on concrete, the concrete should be removed from under the socket as the pipes are laid, and, of course, before the concrete sets, the space being filled with concrete after the joints have been made. Fig. 88 (bottom) illustrates this.

Bedding in Concrete

This is necessary in all but the firmest subsoil. The usual detail as required by the by-laws is illustrated in Fig. 88. Bedding effectively prevents unequal settlement, and drains so laid rarely give trouble, but it is costly and the repairer must bear

The cement joint is brittle and will crack if there is slight unequal settlement. An alternative to cement is a mixture of bitumen and sand boiled and poured into the sockets. Clay must be worked round the joint to prevent the mixture pouring out. There are also various patent joints designed to allow some slight movement without leakage.

Stoneware pipes and traps are illustrated in Fig. 89, and Fig. 90 shows sections through various traps.

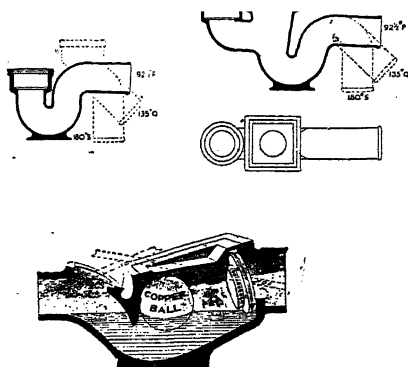


Fig. 90.—TWO ILLUSTRATIONS OF A GULLY TRAP, THE ONE ON THE RIGHT WITH A BACK INLET (Clark Hunt & Co., Ltd.) THE LOWER DRAWING SHOWS AN ANTI-FLOODING TRAP
(George Couzens & Co., Ltd.)

this in mind. If it is necessary to take up drains in concrete to remedy a fault, the section involved must be broken up. Drains without concrete bedding are easy to take up and may be re-used if in good condition.

Drains passing under a building should be entirely cased in concrete. Any leakage under a building is, of course, highly dangerous to health.

Cast-Iron Drain Pipes

These cost more than stoneware, but as they are made in lengths of from 6 ft. to 12 ft., there are fewer joints, and the pipes are stronger. The joints are made with a gasket and molten lead caulked in the spigot, as in Fig. 88B. The pipes are coated with Dr. Angust Smith's solution which prevents corrosion.

Layout of Drains

The following requirements should be observed:—

Straight lines. Adequate falls. Straight inverts. Watertight joints smooth and flush inside. Access for rodding and inspection along the whole of the drain and its branches. Through ventilation. Suitable diameter. Trapped inlets to foul drains. Trap with rodding arm and disconnecting chamber close to the boundary.

For small houses and other small buildings, drain pipes should be 4 in. diameter laid to a minimum fall of 1 in 40.

For large houses and other buildings, drain pipes should be 6 in. diameter laid to a minimum fall of 1 in 60. Branches should be 4 in. diameter. It is rarely necessary to use pipes greater than 6 in. diameter.

Bends of correct radius should be used. Bends should not be made with straight pipes. Proper junction pipes should be used. Pipes should not be broken into to make a connection. Remove a pipe and fit a suitable junction.

Inspection Chambers

Brick or concrete chambers through which the drains pass in the form of half-pipes so that they are accessible for inspection and rodding.

An inspection chamber not more than 3 ft. deep may have a minimum size of 2 ft. \times 1 ft. 6 in. A deeper chamber must allow a man to get inside, but it is rarely necessary to make a chamber larger than 4 ft. \times 2 ft. 6 in.

A disconnecting chamber with rodding arm leading to the sewer connection should be placed where the drain leaves the property. The bottom is of 6 in. cement concrete; the walls of 9 in. brickwork in cement mortar, the interior being rendered with cement. The top is covered with an airtight cast-iron inspection cover and frame set in a concrete curb. There is a fresh air inlet in this chamber at the front boundary.

PRIVATE SEWAGE DISPOSAL

Outside sewered areas sewage from a small property may be disposed of by:

- (1) Earth closets.
- (2) Chemical closets.
- (3) Cesspool, with drain connections from W.C.s.
- (4) Septic tank, with drain connections from W.C.s.

The privy or midden is now considered an insanitary system, and where it still exists should be replaced by a satisfactory system.

Earth Closets

In this fitting, dry earth in a container is mixed with the faecal matter by operating a lever. The earth deoderises and neutralises the faecal matter, and the bucket can be emptied on the land. The neutralised matter is a good fertiliser, and should be dug into the soil.

The earth used should be dry, loamy or vegetable earth. Sand and lumpy clay are unsuitable.

The by-laws require that an earth closet shall:

- (a) Be entered from the open air.
- (b) Be not less than 40 ft. from any well, spring, or stream, the water of which is likely to be used for domestic purposes.
- (c) Be lighted and ventilated into the open air.
- (d) Have a non-absorbent floor with a fall to the door and a level at least 3 in. above adjoining ground.
- (e) The receptacle shall not be connected to any drain.
- (f) The receptacle shall be protected from rain, and be easily accessible, watertight, and of non-absorbent material.
- (g) The receptacle shall have a capacity not exceeding 2 cubic feet (or such less capacity as will contain the accumulation of not more than one week).
- (h) Shall have adequate means of access for the removal of the receptacle.

The fittings are usually very simple and easily repaired. Spare parts can be obtained from the makers.

The Chemical Closet

This is classed as an earth closet in the by-laws, but it is a superior apparatus, and where there is any trouble with the ordinary earth closet, the chemical closet should be recommended as a replacement.

The chemical supplied is mixed with from 3 to 6 gallons of water. In this the faecal matter is immersed and reduced to an inoffensive liquid which can be poured on to the land (from a removable receptacle) or drained through pipes into a soak-away in porous subsoil.

The Cesspool

This is merely a storage tank of brick or concrete. The W.C.s are

drained to it by ordinary pipes, and it is emptied at intervals. Usually the local authority removes the contents.

The by-laws require that a cesspool shall:

(a) Be at least 50 ft. (in London 100 ft.) from a dwelling or other building.

(b) Be at least 60 ft. (in London 100 ft.) from a well, etc., the water from which is used for domestic purposes.

(c) Be provided with means of access and so situated that its contents may be removed without passing through any dwelling-house or building in which persons are employed.

(d) Shall not discharge any foul matter into a sewer or watercourse.

(e) Shall be constructed so as to be impervious to liquids.

(f) Shall be properly covered and adequately ventilated.

Old cesspools in a bad state of repair must be restored so that they are watertight. This involves some repair to the brickwork and the rendering of the interior with a cement-sand mix. It is advisable to add a waterproofing compound to the rendering. A new manhole cover and frame may be required, with concrete curb or paving. The repairer should consult the sanitary inspector first, to be sure that the proposed repairs will be approved.

The Septic Tank

A small septic tank for a private house is illustrated in Fig. 91. This is intended as a typical design which can be built of brickwork, concrete, and glazed stoneware or cast-iron pipes. Firms supplying septic tanks have their own methods of construction and details.

The sewage drains into the first tank. Solids rise to the top to form a scum which should be cleaned off about three times a year. Sludge forms at the bottom and should be cleaned out at suitable intervals. This first tank should be covered, and have an airtight cast-iron inspection cover. The second tank is a filter or aeration bed through which the liquid passes, and is acted upon by aerobic bacteria. The effluent, though dis-

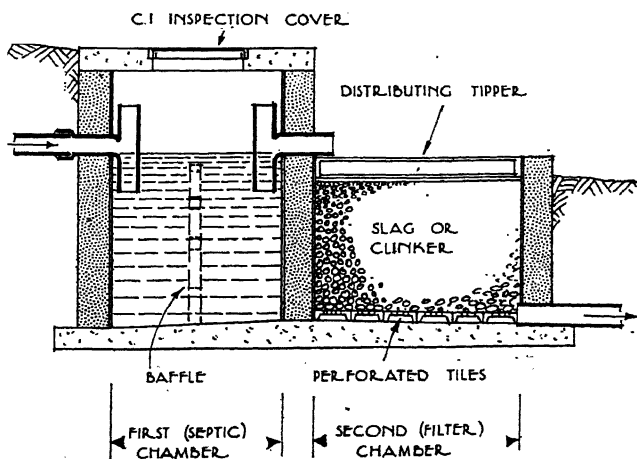


Fig. 91.—SEPTIC TANK

coloured, is harmless, and may be discharged into a stream (in which case it is desirable to allow the rainwater drain to join with it) or allowed to soak into the subsoil.

The size of the septic tank must be suitable. From the average house the sewage discharge is 25 to 30 gallons per person per day. The first chamber should have a minimum capacity of 200 gallons or three-quarters of one days' flow of sewage, whichever is greater. The second (filter) chamber should have a capacity of 1 cubic yard for every 40 gallons flow of effluent. For the needs of a small house a depth of 3 ft. is sufficient.

The filter material should be slag or clinker. Coke is not suitable. The material should be graded with the coarser material at the bottom up to about $\frac{3}{4}$ in. material at the top.

For even distribution it is essential to fit an automatic tipper, as in Fig. 91. Without such a device trouble will be experienced. To allow the clean effluent to drain away special tiles should be placed at the bottom.

The filter chamber must not be covered as the bacteria depend upon a plentiful supply of oxygen from the air.

The discolouration in the effluent discharged from the filter chamber is caused by suspended organic matter called humus. This is inoffensive, but if it is desired to remove this humus in order to leave a colourless and odourless liquid, the effluent from the filter chamber can be passed through a humus chamber to allow the humus to settle. This chamber is, of course, not essential.

Faults in septic tanks are usually due to incorrect design. Compare the section of any septic tank with the example given in Fig. 91. The design may vary but the positions of outlets, etc., should be the same. The filter material is sometimes not suitable. As already stated, slag or clinker properly graded are much better than coke. The filter material may become choked in time, and should then be removed and washed, or new material used. In some cases the filter chamber is covered, and unless there are adequate inlet and outlet ventilators, this will cut off the air supply on which the bacteria depend for life. If there is no automatic tipper or other distribution device, the effluent from the first chamber is not properly and evenly distributed through the filter.

TESTING DRAINS

A preliminary survey of the drainage system should be made and any faults in the layout noted. In particular the positions of air inlets and outlets and of inspection chambers should be noticed.

Inquiries should be made regarding any offensive smells or leakages either inside or outside the buildings.

Mirrors and electric torches can be used for inspecting the drain from an inspection chamber.

The Scent Test

This, though not the best, is the simplest test. For a small drainage system it is effective if properly carried out. For testing an old drainage system it has the advantage of not placing an unfair pressure on the pipes and joints.

A strong-smelling chemical, such as oil of peppermint or calcium carbide, is placed in the drains from the highest accessible point, taking care that the chemical smell is not released into the building while the test is being prepared. The best way is to place the chemical in a jug of warm water and pour it down the open top of a vent pipe. If it is poured into a W.C. pan and flushed through, the smell is released into the building while doing this.

Special containers are made which are filled with calcium phosphide. One of these can be flushed through a W.C. pan. The chemical is automatically released in the drains and with water forms phosphine gas, which has a pungent smell. Fig. 92 (A) illustrates one type. Windows should be closed, and the interior of the building inspected for the chemical smell. The ground along the drainage lines, gulleys, soil pipes, etc. should be similarly inspected. The inspection should be repeated, and if, after an hour, no smell is detected it may be assumed that there are no leaks in the pipes and fittings above ground, though the test is not effective for the drains below ground (unless they are bared).

Fig. 92 (B) illustrates a typical set of drain cleansing rods and fittings; and Fig. 93 the drain stopper with connector used in drain testing.

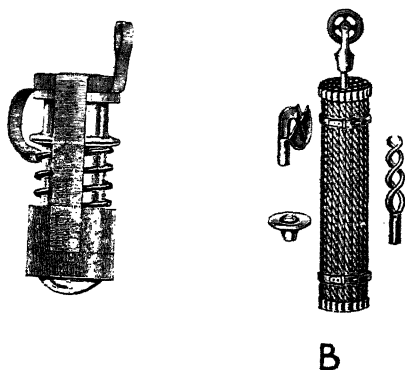


Fig. 92.—(a) KEMPS DRAIN TESTER.
(b) DRAIN CLEANSING RODS AND FITTINGS

THE COLOURED WATER TEST

This is useless as a general test, but it can be used for tracing drains, and in some cases for tracing leaks and obstructions. Potassium permanganate can be used for this purpose—it is red in solution. Fluorescein, which is bright green, is a good alternative.

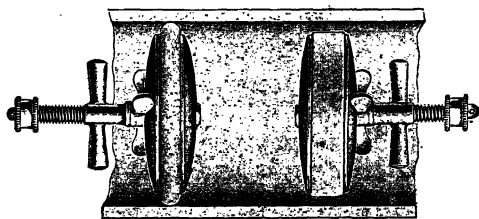
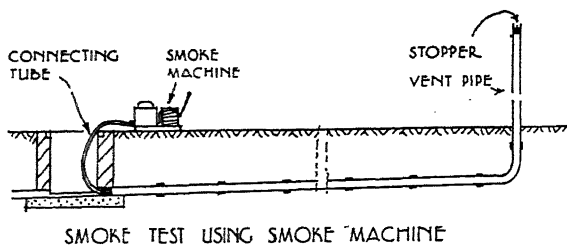


Fig. 93.—DRAIN STOPPER. THE STOPPER IS INSERTED AS SHOWN ON THE RIGHT OF THE DRAWING AND THEN EXPANDED AS SEEN ON THE LEFT

THE SMOKE TEST

There are two methods—by smoke rocket and by a smoke machine.



The smoke rocket is useless as a general test. It merely releases smoke in the drain without generating the pressure necessary to force it through slight leaks. But it is useful in locating obstructions and tracing connections.

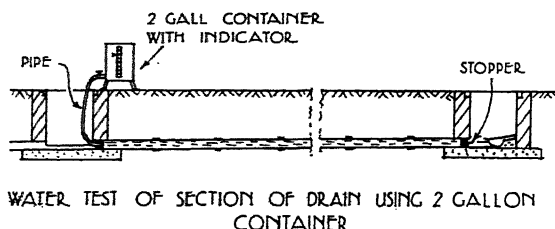
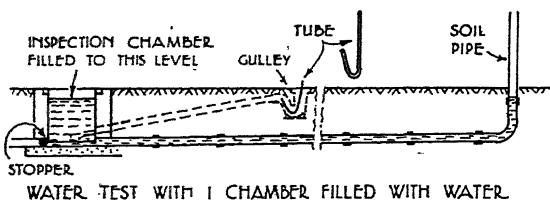


Fig. 94 (top), Fig. 95 (centre) and Fig. 96, ILLUSTRATE SMOKE AND WATER TESTS FOR DRAINS

Traps must have the normal seal, and when the smoke rises to the top of vent pipes these must be stopped. The best type of smoke machine has a water sealed dome which rises as pressure is generated with the bellows. Too much pressure will allow the smoke to rise through the traps. If there are no leaks the dome of the machine will remain elevated.

THE WATER TEST

This is the most reliable test. The drains may be tested in sections, or the whole system including the interior pipes and fittings may be tested. An expanding rubber stopper or a pneumatic stopper is used to close the lowest accessible point of the drain. To prevent air lock in any unventilated branch, a bent vent pipe is inserted in the trap, as in Fig. 95.

In its simplest form, the water test is made by filling the lowest

inspection chamber (first stopping the outlet), marking the level of the water and then observing the level. Any considerable fall indicates a leakage, but there will be a slight fall due to absorption of water into the porous rendering of the manhole.

A better method is to use a special measure of 2 gallons capacity. This is filled and connected to the drain with a flexible tube, as in Fig. 96. With a graduated scale any fall of water can be measured.

The objection is sometimes made that this test is too severe for an old drainage system. But as a stoppage (which is liable to occur in any system) at a low point would set up a similar pressure, the test is a fair one.

Chapter XVII

WATER SUPPLY

THE sources of pure water supply are:

- (1) Water authority's main.
- (2) Rainwater, filtered and stored.
- (3) Shallow well (lined with brickwork, etc.).
- (4) Shallow well (tube well).
- (5) Deep well.
- (6) Pure stream (using pump or hydraulic ram).

Of the first source we need only say that the authority's regulations must be observed in new and repaired service pipes and fittings.

COLLECTING AND FILTERING RAINWATER

Where a supply cannot be taken from a main and for some reason a well is not practicable, roof water may be collected, filtered, and stored. From the storage tank it can be pumped into small tanks in the roof of the building.

Water collected from tiles and slates in rural areas is not seriously contaminated. Water collected from lead and zinc roofs is also suitable in a clean country atmosphere, but in urban and industrial areas the acids in the atmosphere dissolve the metals and pollute the water. Water should not be collected for use from felt or dyed roof coverings.

Cast-iron gutters and down pipes should be coated inside with Dr. Angus Smith's solution. Down pipes should be connected direct to glazed stoneware or coated cast-iron pipes, socketed and jointed. Traps should not be used.

The filter and storage tank may be arranged in a variety of ways, but it is advisable to consult the local surveyor or sanitary inspector about the design. The tank interiors should be rendered with water-proofed cement and sand mix, including walls, bottom and top. Walls, floor and top must be impervious. Inspection covers with air-tight frames should be fitted.

A supply pipe of at least 1 in. internal diameter is taken from the bottom of the storage tank and connected to a pump in the house with the delivery pipe connected to a storage tank in the roof. This tank should be covered. Either a semi-rotary hand pump or an electric pump can be used.

The capacity of the storage tank and filter depends on the requirements of use. For domestic purposes 20 gallons per head per day is a reasonable supply, with a minimum capacity for the storage tank of

1,500 gallons. This will supply a family of three for 40 days, or with economy considerably longer. Even so, in an exceptional drought period the supply may be exhausted.

The filter tanks must be cleaned frequently, removing the sediment from the settling chamber, and the charcoal must be changed. The equipment will be periodically inspected by the local sanitary inspector. Any pollution of the water is sure to be due to leaky pipe joints, and if near a leaky drain such pollution is serious.

SHALLOW WELLS

This is the type of well commonly found in rural districts. Permeable subsoil overlying an impermeable stratum becomes saturated with water (provided the shape of that stratum is suitable) and thus water is collected into the bottom of the well, and can be pumped to the surface.

Fig. 97 illustrates a typical brick-lined well repaired to keep out polluted surface water. The interior is rendered with a waterproofed cement mix from the top down to the plane of saturation. Below that plane the lining is porous so as to admit water.

If an old well lining is in bad condition it should be lined with concrete pipes, the space between the pipes and the brickwork being filled with fine concrete. The pipes below the plane of saturation should have holes to admit the water.

The surface surrounding the well should be paved with concrete, as shown in Fig. 97, and sloped away from the well head so that surface water is drained to a channel and carried into the drains. It is desirable to grow grass for some distance around the well. This acts as a surface filter, and reduces the risk of pollution. Cattle should not be allowed on this grass anywhere near the well. A cesspool should be at least 60 ft. (in London 100 ft.) away from the well, and it must be remembered

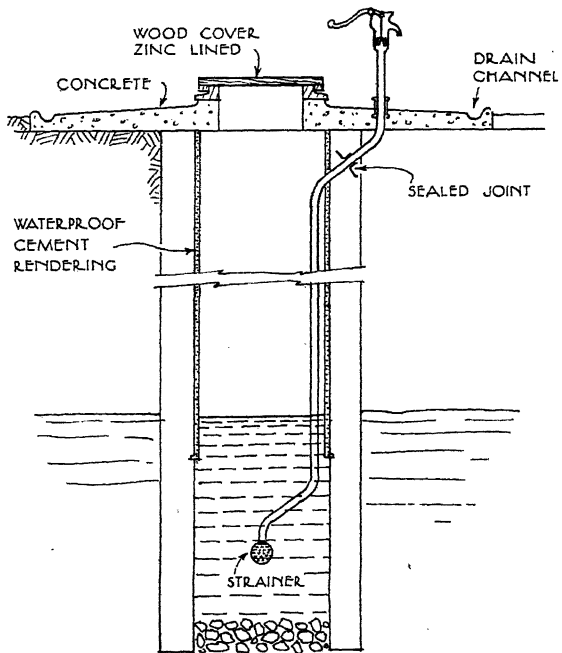


Fig. 97.—SHALLOW WELL.

that leaky foul drains will pollute the water. The well top should be covered with a weatherproof zinc-lined wooden manhole cover, secured with a lock.

PUMPS

The ordinary manual suction pump should not be more than 25 ft. from the surface of the well water to the pump valve. Pipe joints must be watertight. A strainer should be fitted at the end of the pipe, and should be at least 2 ft. from the bottom. The pipe should be brought through the side of the well near the top (making a watertight joint in the well lining) so that the pump can be fixed at the side.

Where the water-bearing subsoil is gravel, a metal tube well is satisfactory. The tubes are screwed together in lengths as they are driven into the ground, the bottom tube being fitted with a strong steel point and having perforations to admit the water. The pump is fixed to the head of the tube. On first operating the pump a little sand will be drawn up with the water, but this is soon cleared and with the perforated bottom tube surrounded with clean gravel, pure water is then drawn up.

Repairing a Pump

Common faults are: Leaking suction pipe causing loss of water. This can be detected by inspecting the pipe from a ladder let down the well. On working the pump handle water will spurt through any leak.

Leaking tail valve causing the water to fall back into the well. The tail valve should be removed and a new one fitted. A new valve may be cut from a suitable piece of oiled leather, taking the metal weight from the old valve and refixing on the new. This weight causes the valve to fall quickly and prevents the water falling back into the pipe.

The iron or wood bucket in the pump is fitted with a clack valve which allows the air to escape as the bucket goes down and traps air as the bucket rises. As this bucket rises and falls the effect is to extract air from the suction pipe until a partial vacuum is created and atmospheric pressure forces water up the pipe. Any fault in the bucket and clack valve results in a falling off in the volume of water raised. Grit may stick in the valve or the seating may be badly worn. If the bucket is in bad condition it should be replaced with a new one.

In reassembling a pump care should be taken to bolt up tightly so that no leaky joints are left.

DEEP WELLS

Water between two impermeable layers is usually quite pure. As it is under pressure it will often rise to the surface by its own pressure. This type is called the artesian well and is valuable where large supplies are required. Sinking and repairing artesian wells is a specialist's job.

THE HYDRAULIC RAM

Where a pure water supply can be obtained from a stream, the hydraulic ram can be used to raise the water automatically to a higher level. No motive power is required, and the only moving parts are two flap valves. This system is installed by the manufacturers and should be repaired by them.

SOFTENING WATER

Hardness in water is due to calcium and magnesium accumulating in the water as it passes through the earth. Hardness is measured in English degrees, and varies from about 4 to 50 degrees, a definitely soft water being less than 5 degrees, and moderately hard 5 to 15 degrees. In London it is 16 degrees. The minerals in the water are deposited on the inside of kettles, boilers, circulation pipes and tanks. There is also difficulty in obtaining a soap lather.

Water Softening Apparatus

Apparatus used to soften hard water. The apparatus must be suitable for the water used, and be of adequate capacity. A reputable firm will examine a sample of the water and supply suitable apparatus.

The formation of scale and fur from hard water increases with the temperature, so that it is particularly troublesome in hot water systems. Slight hardness is no disadvantage, as the deposit is formed very slowly and furnishes a protective lining to the pipes and tanks. Indirect circulation with a coil heater is recommended where the water has pronounced hardness.

Chapter XVIII

HEATING, LIGHTING AND POWER

ALL but the simplest repairs of heating, lighting and power installations should be placed in the hands of the appropriate specialist, but a knowledge of certain faults and repair methods is useful to the general repairer.

HEATING AND HOT WATER

Excessive heat loss in very cold weather is a fault in some installations with extensive pipe lines. High fuel consumption is a result. The remedy is to lag the pipe lines with insulating material such as felt or asbestos jacketing. These materials are obtainable in a conveniently prepared form.

Boilers of the open type are also liable to radiate a considerable amount of heat. This too may be cured by lagging the boiler with suitable insulating material.

Domestic Hot Water Supply

In the tank system the tanks are usually placed in a cupboard in the bathroom. If the cold feed tank is placed at a low level the velocity of flow from upstairs hot taps is rather slow. Placing the cold feed tank in the roof gives a higher velocity of flow, but it should be cased with insulating material to prevent freezing.

Faulty water circulation may be due to faults in the layout. The well-known principle of hot water circulation should be remembered: That water rises when heated and returns in a circuit to the heat source. In a pipe circulation system the heated water rises from the boiler up the flow pipe to the hot tank, into which it is delivered near the top, and back through the return pipe connected from the bottom of the tank to the bottom of the boiler. The flow pipe connection should be at the very top of the boiler and the pipe should not stand into the boiler, otherwise air will be caught and compressed in the top of the boiler, and will then travel through the circulation system, making disagreeable noises. This fault is common.

Failure of Water to Get Hot

This is often due to incorrect connection of the flow pipe to the tank. This connection should be 5 or 6 ins. from the top of the tank. If much higher up than this the water will get hot more rapidly, but will be of insufficient volume. If much lower, the water

will take longer to get hot, but there will be a greater volume of water for drawing off. So it is a matter for compromise.

The return pipe should be connected to the bottom of the tank. In some cases it is connected a little way up the tank, and the water below the connection does not circulate, so reducing the effective capacity of the tank.

The Expansion Pipe

This pipe should bend over to discharge in the open over the cold feed tank. An expansion pipe taken through the roof to discharge in the open air is liable to freeze, with serious consequences. In an existing installation such pipes should be lagged with insulating material.

The hot water supply pipes should be taken from the expansion pipe just above the tank, and the pipes should be fixed to a slight fall.

Circulating pipes which have to run horizontally should also be fixed to a slight and even fall, with frequent fixings to prevent sagging. If both hot supply and circulation pipes are taken as directly as possible with proper falls from point to point there will be no trouble with air lock. Bends of large radius are also desirable.

The cylinder system has certain advantages over the tank system. A quicker supply of hot water is obtained, with a more rapid circulation. This is of particular advantage where, if a tank system were adopted, the tank would have to be a considerable distance from the boiler.

Auxiliary Heaters

Gas or electric heaters are useful for stimulating the circulation of a defective system, or as a stand-by when it is not desired to light a fire in the boiler grate. There are many types. A gas storage heater is a useful type. This can be fitted to an existing circulation system, but a two-way valve must be fitted and closed when the gas heater is in use.

An electric immersion heater can also be used for speeding up hot water supply, or as a stand-by. The immersion heater is fitted to the hot water tank.

Geysers, gas or electric, can be fitted to give point supplies.

CENTRAL HEATING

A good test for a heating system is to take interior temperatures in very cold weather. The following temperatures are adequate:

Halls, landings and bedrooms	..	..	..	55 deg. Fah.
Living rooms, dining rooms, etc.	..	..	..	65 deg. Fah.
Factory, heavy manual work	..	..	..	55 deg. Fah.
Factory, light work	..	..	..	60 deg. Fah.
Offices and schools	..	..	..	60 to 65 deg. Fah.
Warehouses	..	..	..	(to suit the goods stored)
Churches	..	..	..	55 to 60 deg. Fah.

These are average temperatures. Unfortunately many heating

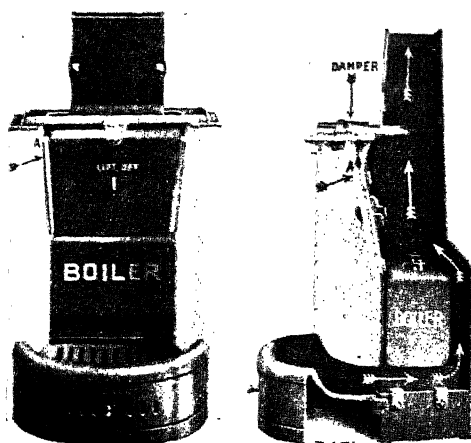


Fig. 98.—GRATE WITH BOILER, COMPRISING SELF-CONTAINED IRON BOILER FLUE WITH SIDE BRICKS, LIFT-OFF BACK PLATE AND PULL-OUT DAMPER, WROUGHT WELDED BOILER, STOOL BOTTOM GRATE AND BERLIN BLACKED FRET WITH DRAUGHT REGULATOR. SUITABLE FOR FITTING AT BACK OF ANY TILE SURROUND WITH 16 IN. FIRE. (Clark, Hunt & Co., Ltd.)

systems give a high temperature in one part of the room and a low temperature in another. Attention should be given to draughty windows and doors, and to insulation of walls, ceilings, and roofs (see Chapter XV).

Thermostatic Control

This is an automatic heat control system by which a thermometer device fixed to the wall of the room controls the heating system, and keeps the room at a predetermined temperature. The control may operate on the gas, electricity, or oil supply, or on the damper, in the case of solid fuels. This automatic control makes for fuel economy and comfort and labour saving.

Automatic stokers for solid fuel and oil fuel are now widely used.

RANGES

The old type kitchen range has separate parts, which are put together by the bricklayer. The modern combination range is self-contained. All ranges should be set strictly to the makers' instructions. Fig. 98 illustrates a typical modern self-contained grate, with back boiler for domestic hot water.

The narrow internal flues of the combination range may become clogged with soot, and this is sometimes mistaken for faults in the range. Any broken parts should be replaced with new parts obtained from the makers of the range—such parts are readily obtained from stock.

Repairing Fire-Brick Linings

The best fire-brick linings crack in time. Special fire-resisting cements are made for repair work. There are several proprietary brands. Pointing a narrow crack or fissure is not satisfactory, as the cement soon drops out. If the cracks are widened and undercut the cement holds better. It is always more satisfactory to take out the defective portion and replace with new. In the case of a fire-brick grate interior which is generally defective, it is certainly not worth while to repair with fire-

resisting cement, though there may be some difficulty in finding an interior of suitable shape.

Flues and fireplaces are dealt with in Chapter IX.

If the internal grate flues are clear, and the oven or the water does not get hot enough the dampers should be examined. They may be damaged or displaced.

Portable or closed ranges and boilers are convenient for installation in existing buildings. A solid hearth and a flue must be provided, the flue usually being of iron taken through an outside wall and secured to it with holdfasts. These flues rust in time, but replacement is not difficult. It is, of course, better to build a brick flue, taking care to bond it properly to the existing wall.

VENTILATION

Mechanical ventilation is the specialist's job, but some principles of ventilation may be usefully stated.

Rate of air change should suit the purpose of the building. It has an important effect on heating. The usual rates of air change are:

	<i>Changes per hour.</i>					
Domestic buildings	1½ to 3
Public halls and churches	1 to 1½
Hospitals	2 to 3
Garages	1 to 4
School classrooms	3 to 4
Factories	1 upwards.

In factories the processes employed must be carefully considered. Special ventilation and dust extraction are necessary in many cases. Ventilation systems must comply with the factory acts. The factory inspector will give advice.

For natural ventilation in small rooms air bricks with interior baffles should be fitted. If they are draughty the addition of an exterior baffle will usually cure the trouble.

An open solid fuel fire provides good exhaust ventilation, as also does a gas fire with a proper flue outlet. Where an electric fire is fitted no flue ventilation is provided, and the room may be badly ventilated. To improve the ventilation, fit an air inlet ventilator near the floor and an outlet ventilator near the ceiling, preferably on opposite sides of the roof, but taking care to avoid a draught (not an easy matter to plan). The inlet ventilator should have an adjustable baffle.

For additional ventilation the vertical sliding sash window is probably better than the side and top hung casement, especially if a deep bead is fitted to the back of the sill to prevent draught.

In a casement window with side hung casements it is a convenience to add a small top hung casement for weatherproof ventilation, as already illustrated in Fig. 52 (D).

The simplest means of providing additional ventilation in factories

and halls is by fixing extractor ventilators in the roof. They have fixed blades so shaped that the wind forms a partial vacuum in the enclosure, thus extracting the air from the building. There are no moving parts. There must, of course, be adequate air inlets to the building.

Exhaust fans electrically operated, placed high up the walls in louvered enclosures assist ventilation in positions where natural ventilation is inadequate. With forced ventilation air supply can be exactly regulated.

LIGHTING

In deciding the colour of decorations the reflecting power of the coloured surface should be considered. Considerable economy in lighting can be effected by having surfaces of light colour, as indicated by the following table:

<i>Colour.</i>	<i>Percentage of light reflected.</i>									
White	84
Ivory	73
Light grey	70
Primrose	70
Satin green	63
Buff	60
Pink	50
Stone	47
Pale blue	39
Bright green	38
Olive green	21
Cardinal red	16
Chocolate brown	16

With dark coloured surfaces indirect lighting by reflection from the walls and ceiling is obviously unsuitable.

ILLUMINATION FAULTS

Illumination concentrated at one point is generally a common fault, though it is useful for special purposes. In a room more than 20 ft. long, with a height of from 8 to 10 ft. it is much better to have two lighting points than one.

For industrial, shop, and office lighting special fittings are made which give uniform distribution, and, though costly, result in considerable economy.

For shop window lighting there are two types of reflector in use: the intensive and the extensive. Intensive reflectors usually have horizontal mouths, and are intended for windows of which the depth is equal to half or less of the height. The extensive type has the mouth at an angle to the horizontal so that the light can be projected to the back of a deep window. The lights should be concealed from outside by a pelmet, or placed above a false ceiling.

The most common fault in lighting is glare. The light source should be concealed from any ordinary viewpoint. It should not be visible when working, reading, or gazing in a horizontal direction.

Opal bowl and globe fittings are good as they diffuse light and reduce glare, but they absorb a considerable amount of light, especially if tinted. The coloured light from a tinted fitting is usually not agreeable.

ELECTRIC INSTALLATIONS

This work is specialist, and should be left to the electrician. Minor repairs to actual switches and fittings may be safely carried out, however, provided elementary precautions are taken.

Before attending to switches and fittings place the main switch in the off position. This is a double-pole switch which renders both wires dead. The ordinary wall tumbler switch breaks the circuit in one wire only—the other remains alive and, if touched, may give a dangerous shock, unless rubber gloves are worn.

Switches

Switches wear at the contacts, owing to slight sparking, resulting from constant operation of the switch. Unless badly worn, the contacts can be cleaned with fine emery paper, and adjusted to make good contact when the switch is closed. Remove the loose emery by blowing.

If there is any vibration the wires may become loose in the switch terminals: these are easily tightened with a small screwdriver.

Switch socket-plugs have two or three sockets for use with a two or three-pin plug. The third pin is for earthing, so that the metal case of the electric iron, fire, or other equipment can be earthed. This is a precautionary measure. Through carelessness some three-pin plugs are not "earthed." The earth plug should be connected to a lead or copper water pipe with a bare copper stranded wire. Do not connect to gas pipes.

The connection to the pins of the plug may become loose. Remove the cover and tighten the terminal screws, making sure that the wires are in position. Clean the ends of the wires.

The flex, or cable, connecting the plug and the portable equipment tends to wear where it enters the plug at one end and the equipment at the other. In some cases rubber sleeves are fitted. Wear can be prevented by winding a piece of insulation tape round the flex at these points. This must be done after removing the flex from the plug or equipment. If the braided covering of the flex is frayed it should be covered with insulation tape to prevent further wear.

The flex used with portable equipment is liable to be damaged, so that the wire strands break. This may cause sparking, shorting, or render the circuit dead. If the break is near the end of the flex, the flex can be cut above the break, and the ends of the wires bared to make a new connection. No attempt should be made to splice a break, as it

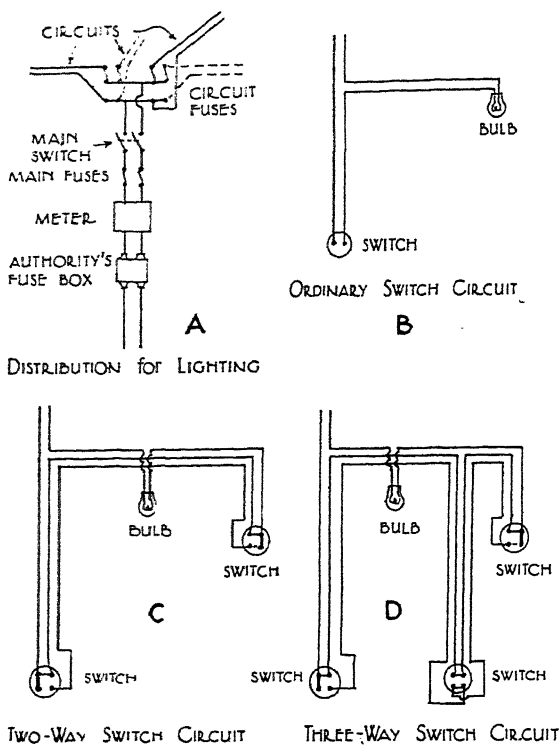


Fig. 99.—ELECTRIC WIRING

switches, and distribution fuse board for a small building. Power supply is often fed through a separate meter and fuses.

Fuses are rated by current capacity: 5, 10, 15 amps., and so on. Where there are separate fuses for each lighting circuit, a 5 amp. fuse is suitable for ordinary bulbs. For a 2 unit electric fire a 15 or 20 amp. fuse is suitable. Fuses should have adequate capacity—three times the maximum working load is not excessive. A fuse of relatively low capacity is liable to blow at the slightest overload.

Multiple-Way Switches

The ordinary switch circuit is illustrated diagrammatically in Fig. 99(B). It is convenient with many lighting points to have two-way switch control, as in Fig. 99(c), and in some cases three-way control, as in Fig. 99(d). There are several special switches, such as the master switch for special controls.

Switches in damp positions and outside should be of the watertight type.

cannot be satisfactorily made, apart from the difficulty of insulating it.

Insulating tape is not satisfactory as a permanent insulator. The tacky mastic dries, and the tape may fall off. It is a protective, damp-resisting material, but should not be used on bare wire.

Fuses

These are thin wires placed in a circuit to form fusible links. If the circuit is seriously overloaded the fuse wire melts and breaks the circuit. A blown fuse should not be replaced until the defect which caused it to blow has been found and remedied.

Fig. 99 (A) shows the circuit with main fuses,

ELECTRIC BELLS

These may be battery-operated, but it is more convenient to use a small transformer connected to the mains, which gives a 4 volt output. The bell contacts, terminals, and wire ends should be cleaned occasionally. The set screws which adjust the make and break action are liable to move in time, thus preventing the bell working. By carefully examining these screws and contacts it will be clear what adjustment is necessary to make the bell work again.

The old type wet cells (the Leclanche cell) are now rarely used. Large capacity dry batteries are more convenient.

Chapter XIX

GLAZING AND GLASS

ORDINARY window glass, as used in houses and commercial buildings in panes of ordinary sizes, is flat drawn sheet glass. There are four weights:

Drawn Sheet Glass

Weights and Thicknesses:

18 oz. approx. $\frac{1}{12}$ in. (Weight is in ozs.

24 oz. do. $\frac{1}{10}$ in. per sq. ft.)

26 ozs. do. $\frac{1}{8}$ in.

32 oz. do. $\frac{5}{16}$ in.

Probably the 24 oz. sheet glass is more widely used than the other weights. It is not generally known that each of the above weights is made in three standard qualities.

Qualities:

Ordinary glazing quality.

Selected glazing quality.

Special selected quality.

Drawn sheet glass is not perfectly consistent in thickness, so that there is some distortion of vision, but this is much less in the Special selected quality than in the inferior qualities.

Polished Plate Glass

Thicknesses from $\frac{1}{8}$ in. to $1\frac{1}{4}$ in.

Normal thickness $\frac{1}{4}$ in.

Plate glass is highly polished and has flat surfaces, giving a clear view without distortion. It is stronger, and has higher thermal insulation than the thickest sheet glass.

Qualities:

General glazing quality.

Selected glazing quality.

Silvering quality.

Plate glass should always be used for shop windows, show cases, and wherever clear vision is required. Where rooms face a good view, it is worth while re-glazing sheet glass windows with polished plate glass.

Rolled Glasses

These glasses are designed to obscure the view. There are three main types:

Rough Cast

The surface is slightly irregular on one face or both faces. It is easy to clean.

Cathedral and Figured

Various impressed patterns. The deeper figured patterns are not easy to clean, and often cause dissatisfaction for this reason. The cathedral patterns are not so deeply impressed and most of them are quite easy to clean.

Wired Cast

A wire mesh reinforcement is embedded in the glass. The glass will crack on impact, but will not fly about. It should be used in all roof lights, lantern lights, and also as a protection against fire. The Georgian wired (square mesh) looks better than the hexagonal wire mesh.

SPECIAL GLASSES

A number of problems, such as heat transmission and fading of colours, due to strong light can be solved by using an appropriate special glass. Following are brief particulars:

Toughened Glass

This is used where the glass may be subjected to knocks. It is suitable for shelves, showcases, counter tops, and table tops. Toughened glass has high fire resistance, and may be used (suitably glazed in metal frames) for this purpose instead of wired glass.

“ Vita ” Glass

This glass admits ultra-violet rays from natural sunlight. It is made in sheet, plate, cathedral, and wired.

Non-Actinic

Non-actinic is opaque to ultra-violet rays. It has a slightly irregular texture and greenish tint. Greatly reduces fading action of daylight, and absorbs a proportion of the sun's heat.

Heat-Absorbing

A special glass of greenish-blue tint, absorbing about 80 per cent of the sun's heat for any thickness. Absorbs about 40 per cent of light. Useful for roof glazing and windows in warehouses, factories, garages, etc., which are exposed to the sun. Where the tint and loss of light is not objected to, it should be used to re-glaze any window which admits too much heat. Useful for larders.

Anti-Fly Glass

An amber-tinted glass—the colour is a deterrent to flies and insects. Useful in larders and food storage rooms.

New Crown

Similar to the crown glass found in old windows. It is obtainable in sizes up to 18 in. \times 12 in., and should be used for re-glazing windows in old buildings where it is desired to maintain the character of the glazing.

Prismatic Glass

Parallel prisms on one side arranged to refract the light passing through the glass. Used in windows which are shaded by high buildings opposite, or where the rooms are deep and window area is at one end only. The effect of the glass is to direct the light rays horizontally into the room.

GLAZING METHODS

For glazing in wood ordinary putty is used consisting of raw linseed oil mixed with powdered whiting, with a little turps added to assist drying. A powder pigment may be added for colouring.

Putty on wood sometimes cracks badly. This may be due to the wood not having a priming coat before glazing, the result being that the wood rapidly absorbs the linseed oil and the putty shrinks. Another cause is the putty being left for a long period without painting. The putty should be painted over as soon as it has reached a reasonable degree of hardness. If it is painted too soon it will remain soft for a long time.

Putty for metal frames consists of raw linseed oil, powdered whiting, white or red lead, and manganese dioxide. It is better to use a proprietary make of metallic putty. Ordinary linseed oil putty should not be used on metal frames.

For glazing in stone and concrete grooves, Portland cement and sand, mixed 1 part to 1 part, is used. In stone mullions a mastic consisting of earthy sand, litharge, and a small quantity of gypsum is used.

Leaded Lights

These should be glazed with metallic putty. This should be done with care or leakages will appear. Small leaks may be stopped by making good with metallic putty, working it in with a knife. Do not use ordinary putty for this purpose.

Poor quality leaded lights are subject to a number of defects—leakage, corrosion, and distortion. Inferior lead is used in the cheapest lights. It is soft and easily corrodes in a polluted atmosphere.

Distortion should be corrected, and metal saddle bars should be fixed to prevent a recurrence. The lead comes should be wired to the saddle bars. For large lights copper comes are now largely used instead of lead, as copper is stronger, and a smaller section can be used.

Pavement Lights

Of the old type, consisting of glass lenses or prisms set in a cast-iron frame, are liable to develop various defects which are avoided in the newer pavement lights. Reinforced concrete is now extensively used for the framing, the lenses being fixed with an insulating mastic. These lights are also employed to make flat glass roofs. There is no exposed metal, corrosion cannot occur, and no painting is required.

Pavement lights may develop leakages, which can be stopped by using an appropriate mastic. Cracked lenses should be cut out and replaced with new. If the defects are more than few, the work should be placed in the hands of one of the specialist firms—preferably the makers of the lights.

Trouble is sometimes experienced with condensation under pavement lights. A cure can sometimes be affected by fixing an electric heater or radiator near the floor, and providing ventilation near the lights.

GLASS BRICKS

These are hollow, and of moderate weight. The edges are treated with a special paint, and sanded to allow the bricks to be laid in ordinary mortar. They are laid like ordinary bricks, but must not be used for load bearing. A panel of glass bricks may be built into a wall where light is required without ventilation or view. The sound and thermal insulation is much higher than for sheet or plate glass.

The outer edge of the panel should be jointed in suitable mastic.

The makers' instructions should be followed in fixing, and any defects should be referred to them.

GLAZING BARS FOR ROOFS

The glazing bars should be of wood, metal or pre-cast reinforced concrete. Typical wood and metal bars are illustrated in Fig. 100. The common wood putty glazing bar or rafter is liable to rot if the painting is neglected or the puttying leaks, and the rigidity of the fixing may cause the glass to crack. Bending,

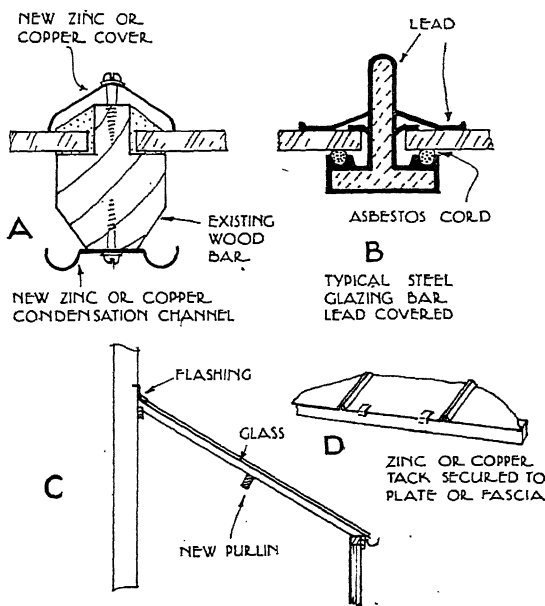


Fig. 100.—ROOF GLAZING



Fig. 101.—POINTING LEAKY GLAZING BARS WITH
"PLASTALEKE" (George M. Callender & Co., Ltd.)

are many proprietary makes and sections. These bars are excellent, and if the right size is selected for the span they rarely give trouble. Occasionally the lead covering lifts, but this can be dressed down. Some metal glazing bars, made during the war, have bituminous felt capping. This should be replaced with lead.

Condensation occurs under roof glass, and it is an advantage to have bars with draining channels under. Wood bars which lack these grooves may have drainage channels added, as in Fig. 100 (A). If glazing bars tend to sag, a purlin should be added to give necessary support, as in Fig. 100 (C).

End clips are fitted to the ends of proprietary puttyless bars to prevent the glass slipping. If slipping occurs with wood bars, zinc or copper tacks can be added at the eaves to secure the glass, as shown in Fig. 100 (D).

Leaky roof glazing can be pointed with a suitable mastic, as in Fig. 101.

CLEANING WINDOWS

Regular cleaning is necessary not only for appearance sake, but to preserve the glass against attack by acids in a town atmosphere.

Window cleaners use skrim—a kind of sacking material. It should be boiled before use. The skrim is used with water for removing the dirt. One leather is used for washing, after using the skrim, and another leather for polishing. A small knife is used for removing grease spots, taking care not to scratch the glass. A very thick grime may be removed with a weak solution of oxalic acid, which should be washed off afterwards.

Metal polish may be used to give a high polish to glass. When polishing plate glass soft wash-leather gloves should be used. Paraffin should not be used for polishing as it smears and clouds the glass when slightly heated.

warping, and shrinkage may also crack the glass.

Puttyless glazing bars are now widely used for roof lights. Fig. 100 (B) shows a typical example. A metal covering is used, and the glass rests on asbestos cord seating. Efficient weather checks are provided, including, in some cases, condensation channels. Metal bars are either galvanised or entirely sheathed in lead. There

Chapter XX

PAINTING AND DECORATING

ON any building it pays to use only the best quality paints. Failure of paint coatings on a large building involves costly renewal, and in the meantime wood and steel rapidly deteriorate. Although the deterioration of paint coatings is inevitable, it should be gradual and consistent, and should continue to protect the wood, metal, etc., to the end of its working life.

Some knowledge of the chemistry of paints and the materials to which they are applied is necessary if failure is to be avoided, and faults diagnosed and remedied. The effects of atmospheric conditions and pollution, fumes, industrial chemicals, etc., must also be studied.

WHITE LEAD

The best white lead paint is still the most reliable base and pigment. Only guaranteed genuine white lead should be used. It is made as unadulterated white lead and in four degrees of adulteration:

No. 1, 70 to 80% white lead.

No. 2, 50 to 60% do.

No. 3, 40 to 50% do.

No. 4, 20 to 30% do.

No. 1 has good lasting properties. Barytes is the usual adulterant.

White lead is usually supplied in paste form, containing about 10% linseed oil. In this form white lead sometimes develops the defect of "chalking," so that it easily rubs off. To prevent this trouble, add about 15% of best outside varnish to the raw linseed oil.

Effect of Fumes

Sulphuretted hydrogen is commonly present in a town atmosphere. It discolours white lead. In a polluted atmosphere it is, therefore, advisable to use white lead for undercoats only, finishing with another material.

Apart from discolouring, white lead stands up to sulphuric and other fumes very well. Under the influence of the fumes, white lead forms stable and insoluble compounds which, in effect, form a protective coating against further chemical change.

White Lead Poisoning

This can be avoided by keeping the skin free from white lead. Home Office regulations specify the precautions required by law. Wet rubbing, and use of a waterproof sandpaper, should be adopted. White lead is

not prohibited for any purpose. The law relating to its use provides for cleanliness only.

White Lead Paint

The following is a suitable mix: Three parts white lead to one part zinc oxide; add about 20 per cent of varnish or enamel to the finishing coat. Some painters finish with outside varnish, to which they add a little white lead to kill the yellow tone of the varnish.

ZINC OXIDE

This white pigment is often used instead of white lead. It is non-poisonous. It resists the action of sea air better than pure white lead, but for this purpose a mixture of white lead and zinc oxide is often used, with an admixture of varnish in the final coat.

Zinc oxide does not discolour, and for this reason is often used as a finishing coat on white lead undercoats. Zinc oxide should not be described as "zinc white," a loose description by which lithopone is also known.

LITHOPONE

Another white pigment; now widely used instead of white lead for interior work. The best lithopone consists of zinc sulphide and barium sulphate, precipitated during manufacture in the correct proportions. Lithopone to which barium sulphate has been added and mixed is an inferior product.

Lithopone changes colour when exposed to strong daylight, so it should not be used outside, except in undercoatings.

TINTANIUM WHITE AND ANTIMONY WHITE

These pigments are also widely used for interior work. Like lithopone, they change colour when exposed to strong daylight, and should not be used for exterior work unless protected with zinc oxide, enamel, or white lead. Tintanium and antimony whites have excellent body and opacity, work easily and are economical.

DRIERS

These are compounds of lead, manganese, and cobalt. They are made up in paste and liquid form. In paste form they are mixed with whiting, barytes, or other inert material ground in linseed oil. In liquid form driers are concentrated and of much greater strength than paste driers. Paste driers combat the tendency which most painters have to add too much drier. In good drying weather a little less drier should be added. It is advisable to stick to one first-class brand of drier, so that experience teaches just how much to add to suit various conditions.

TURPENTINE AND SUBSTITUTES

While the chief function of turps is to reduce the paint to an easy working consistency, it also produces products which assist drying. Hydro-carbons, often used as turps substitutes, do not assist drying. If a substitute is used it should be of first-class brand. Inferior substitutes leave the paint tacky.

PROPRIETARY MIXED PAINTS

Ready mixed paints are now widely used, though the best cost a little more than hand mixing with good materials. Unless hand mixing is carefully done by an experienced painter, defects often result. There is much to be said for using a first-class proprietary brand of ready mixed paint. Most of these for exterior work consist of either white lead with a proportion of zinc oxide, or zinc oxide with driers, colours, etc. For interior work, lithopone, tintanium white, and antimony white are generally used.

The paint should be selected to suit the atmospheric conditions, with special consideration of atmospheric pollution, and also to suit the material to be protected.

SURFACES

The best paint will not prove satisfactory if the surface material to which it is applied is not clean, dry, and chemically stable.

Woodwork Treatment

This consists of knotting, stopping, and priming. The best knotting is shellac dissolved in methylated spirits, giving two thin coats over the knots. Loose knots, and knots freely oozing resin should be cut out and stopped. For exterior work wood plugs should be used, not putty. Large firm knots should be covered with aluminium or gold leaf.

Stopping can be made up of one-third white lead and two-thirds putty. This is better than whiting and linseed oil.

All woodwork for exterior use should be primed in the workshop so that it will not absorb moisture. To paint on damp wood is asking for trouble—and it is the most common cause of failure, even causing rot in some cases.

Paint and blisters lifting from the surface are often due to dampness in the wood. Heat blisters are common on paintwork exposed to the south. They can be reduced by using good paint in thin coats, and protecting the work with canvas blinds.

Brushwork is rarely defective, if an experienced painter is employed. Three thin coats are, of course, very much better than two thick ones.

Repainting Woodwork

Experience will decide the treatment of the existing paint. Any paint which does not provide a smooth, stable surface should be

removed. Blistered paint, chalky white lead, and thick paint are unsuitable surfaces for repainting.

The blow-lamp is the best means of removal. Chemical paint strippers may contain harmful alkalies which are difficult to get rid of. After using a stripper, wash down thoroughly and repeatedly. After removing paint, rub down thoroughly, and attend to knotting.

If the existing paint is in sound condition, it only remains to clean the surface before repainting. Any dirt, grease or chemicals left on the surface will attack the new paint, and trouble will follow. Wash down with weak soda or sugar soap, then wash down with clean water. Finally, rub to a clean smooth surface.

Painting on Plaster

The traditional method of treating lime plaster is to allow it to dry out before painting. This is sound, but often delays the work by six months. Any moisture in the plaster will force oil paint off the surface. Distempers or flat paints which do not seal the surface may be used on plaster which is no more than moderately damp, with a good prospect of success.

Softening, crumbling, and flaking of paint on plaster is often due to alkali compounds present in the lime, sand, or brickwork. If, however, the plaster is allowed to dry before painting, and remains dry, the risk of trouble from this cause is slight.

Distempers and flat paints often flake off or soften on plasters exposed to a damp atmosphere—as in kitchens and bathrooms. This is due to the alkalies becoming active in the presence of moisture and so attacking the paint.

Efflorescence of salts present in the wall (see Chapter VI) may destroy the paint by pressure from the interface of wall and paint.

Primers and petrifying liquids are often used on plaster to neutralise the alkalies, but proper drying of the plaster is a necessary preliminary to success. These primers are waterproof, and if much moisture is sealed in the wall, sufficient pressure may develop to break up the paint.

Pigments may be attacked by alkalies in the plaster. Prussian blue, chromes, Brunswick greens, and certain organic pigments are vulnerable to such attack. Monastral fast blue should be used instead of Prussian blue—the former being a very reliable pigment.

Painting on Quick-Setting Plasters

This is often done following the trowel on the supposition that this will avoid any harmful effects. An oil paint, by sealing in the moisture, may be subjected to pressure which will force off the paint. A flat porous primer may be used following the trowel, but the plaster should be allowed to dry out before treating with oil paint. A waterproof primer may be used only if the plaster is nearly dry.

Painting on Brickwork, Concrete, etc.

The problems and possible faults are similar in some respects to those found in painting on plaster. Everything points to the desirability of allowing such materials to dry out before applying oil paint.

Flat paints should be used in preference to oil paints where any moisture is present.

Primers of the waterproof type, chemically inert, are often used on concrete, brickwork, plaster, and asbestos-cement. These primers are better and safer than weak acid solutions, which some painters use to neutralise the alkalies present in the wall.

Magnesia fluo-silicate is a good primer. It neutralises the alkalies, and is easy and economical in application.

Painting on Metals

Galvanised iron, when new, does not take paint very well owing to the greasy nature of the surface. After six months weathering it may be painted with a good prospect of success. New galvanised sheets may be treated with a weak solution of soda to remove the grease, afterwards thoroughly washing. But this is not always successful.

It is better to use bituminous paints on iron and steel, also on galvanised iron, than oil paints.

Zinc does not take paint very well. It should be treated as for galvanised iron. Lead, if clean, takes oil paint well.

Aluminium should be painted before the surface oxidises. Clean with petrol, and then give a coat of Japan gold size and turps, wiping off to leave a thin coating.

Iron Chimney Flues

Being kept at a high temperature, these are difficult to paint. Gums and resins should be avoided, and an oil which will not soften at a high temperature should be chosen. China wood oil is suitable, as it hardens when heated. Bituminous paints should not be used, as they soften when heated.

Proprietary paints are made for iron flues. Only a reputable brand should be used—and a type suitable for the temperature should be selected.

Painting Structural Steelwork

New steel should have a coat of boiled linseed oil at the works, first removing all mill scale. A red lead preservative coat should then be given, brushed well in. As soon as possible after fixing a fine graphite paint should be applied, with a finishing coat of oil paint. This is a better treatment than the five or six coats of oil paint usually applied.

Bituminous paints are suitable for steelwork and are especially valuable in damp situations.

Aluminium paint is an excellent protective for iron and steel, provided it is of first-class make. It withstands a fair amount of heat.

Repainting Iron and Steel

The secret of success is to remove all dirt, scale and loose material. This, of course, applies to repainting any surface. With steelwork the process of cleansing is often tedious, and so the work is sometimes imperfectly done. Paint applied over even a slight trace of rust will soon scale off. The surface must be quite dry when the paint is applied.

Repaint steel every twelve months—otherwise spots of rust may develop.

DECORATIVE PAINTS

There are certain special decorative paints, apart from ordinary oil paint. They are often improperly applied and trouble follows.

Enamels are valuable for their high finish, but as they are slightly transparent a pure white undercoat is required. Tintanium white is best for this purpose; as it has an intense opaque whiteness.

Eggshell gloss is sometimes preferred to glossy enamel. The eggshell gloss can be produced by applying a glossy coat with a slight excess of oil before applying the final coat. This glossy coat should be slightly tacky when the final coat of flattening (mixed with turps and a little copal varnish) is applied.

Special flat enamels are made to produce a dull gloss or eggshell finish.

Cellulose Finishes

These are now widely used. They dry quickly, and several coats can be applied in one day. The best makes are reliable, but avoid the cheapest. The best Cellulose finishes resist heat, and are hard and smooth, and easily cleaned. On large areas spray equipment can be used with advantage.

Concrete Paints

There are various kinds. The reputable brands are better and cheaper than oil paint. Concrete paints give a hard, matt, cement-like surface. Some incorporate powdered stone, which gives a better colour than grey cement (for Waterproofing, see Chapter VII).

To obtain a high gloss varnish finish, the coat under the varnish should not contain oil.

Special plastic paints are used to provide a rough textured surface.

Condensation

This is often troublesome on oil painted and other impervious surfaces (see Chapter VII). It can sometimes be cured by painting with an anti-condensation paint, such as Cork-Tex—a paint of thick consistency that insulates the cold surfaces of interior walls, steelwork, pipes, etc., keeps them dry and prevents rust. Cork-Tex is not decorative, and should be finished with a flat oil paint, or a water paint.

Fading

The fading of pigments is often troublesome, particularly in the red range of colours. Brunswick greens and Prussian blues also fade. Permanent red is reliable, and also Monastral fast blue, already mentioned. These two colours are costly, but colours which rapidly fade merely waste money.

Discoloration

This occurs on walls or ceilings which have been whitewashed or distempered. Extra coats usually fail to cure the trouble. Two coats of white knotting with a coat of white flat paint should be given.

Distemper

The washable type is more easily applied to a plastered surface after first applying a coat of clairecolle (made by mixing glue with whiting and a little alum—or powder size instead of glue). Clairecolle prevents suction and allows the distemper to be more easily applied. If the amount of size or glue is excessive, flaking will result.

PATTERN STAINING

The pattern stain of joists, studs and laths is sometimes very marked. It is due to smoke and dust deposited on the plaster by thermal precipitation. The cooler the surface, the greater the deposit of dust, so that more dust is deposited on the surface between laths or joists, than on the surface over them. Where the temperature of the ceiling or partition can be maintained at about the same temperature of the room, there is very little pattern staining.

Insulation of the ceiling or partition to maintain an even temperature is the only cure. With existing work, thick fibre board, strawboard, cork, or Cabot's quilt should be fixed between the joists or studs.

Hard gypsum plasters are affected by pattern staining to a greater extent than lime plaster.

STAINING FLOORS

A good oil stain should be used. Finish with a coat of hard varnish: if allowed to dry thoroughly before walking on, this will wear very well.

Water stains raise the grain of the wood. Spirit stains show joins, and the work should be completed in one operation to avoid this. Varnish stains are easily damaged.

WALLPAPER

Good quality wallpapers are proof against fading from strong light and slight damp.

In hanging papers the joints should lap "into the light," so that shadows are not cast along the edges. If, in addition, the joints lap away from the doors, the edges will not be noticed on entering the room.

The type and condition of wall surface must be considered. New gypsum plasters with a hard glossy finish present a difficulty. If ordinary paste is used without further preparation, the paper will probably spring off. Such smooth plaster should be sandpapered. The addition of a little castor sugar or glycerine to the paste assists adhesion.

New plaster should have a preliminary coat of size. If the wall is damp a coat of petrifying liquid should be applied.

Paperhanging on Old Walls

This presents two difficulties. First, the removal of the old paper; second, the repair of any bad patches of plaster. In some cases the plaster is so bad that when the old paper is removed the whole of the plastering comes away.

It is very bad practice to paper over old dirty paper. In any case, not more than two thicknesses of paper should be allowed.

If there is difficulty in removing old paper, thorough preliminary soaking with warm water is a great help. Paper on plaster with a coarse surface is particularly difficult to remove, as the porous plaster sucks the paper in with the moisture.

On soft plaster it is advisable to use a lining paper before applying the decorative paper.

In some cases chemicals in the plaster attack the wallpaper. A coat of petrifying liquid will usually prevent this.

Relief Materials

Lincrusta, and Anaglypta, require a strong paste with the addition of about one-quarter by volume of hot glue. The manufacturers' instructions should be followed in applying these materials.

Chapter XXI

ALTERATIONS AND EXTENSIONS

THE first thing to consider, from two aspects, is the effect of the proposed alterations or extensions on the existing building; namely, the plan and the structure.

PLANNING

Some compromise may be necessary between a convenient plan and an economical structural scheme, but it is always desirable to spend a little extra to obtain reasonable convenience in planning. A convenient plan saves money in everyday use, so it is worth extra initial expense.

Any extensive alterations give an opportunity for the replanning of the whole building. Many commercial and industrial buildings consist of a badly planned collection of small buildings, divided by partitions, with long passages, and unnecessary dispersal of the various departments. Obviously time and money is wasted in working in such a building.

The replanning scheme should aim at reducing the distances people have to walk in the course of their work and by which goods have to be moved. The result of a good scheme is seen not only in reduced man-hours, but in extra space. In a badly planned layout there are many odd corners which add up to a considerable wasted area.

Where there is a group of small buildings, it is best to pull them down and make a fresh start. Such buildings are not usually very high, and they may remain in use while a new building is erected over the existing.

A planning point to watch is that a new extension may reduce the daylight in the existing building. In some cases it is necessary to provide extra windows or roof lights in the existing building.

Existing drains may have to be taken up or diverted. Drains under a building must, of course, be cased in concrete.

Floor to ceiling heights, column-free spans, lighting, access, emergency exits, lavatories, and required floor area are the chief points to watch in planning.

ALTERATIONS

The effect of the alteration on the existing structure must be carefully considered, especially from the loading aspect. For example, to cut a wide opening in a wall and place a beam over it, places extra load on the wall under the beam ends. Stress alteration must also be considered. An example of this occurs when a wall is built, or a beam placed, to give extra support to an existing floor or beam of reinforced concrete. If this support is provided in the middle, the stress distribution in the beam or

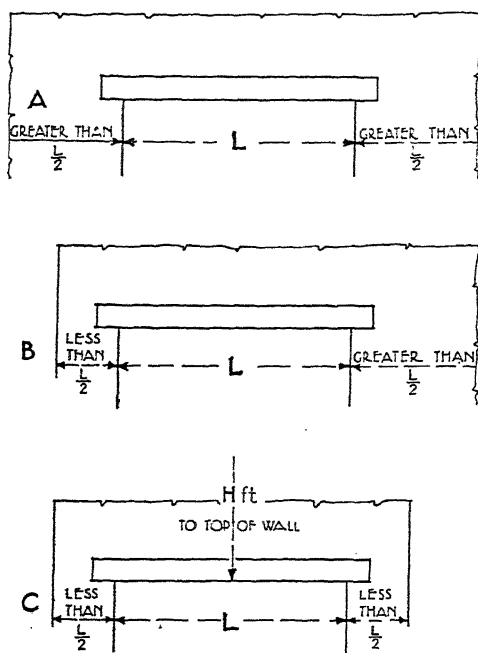


Fig. 102.—HOW TO CALCULATE LOADS FOR LINTELS IN BRICK WALLS

Properly bonded brickwork has an arch effect over an opening, and the area of wall to be supported on the lintel usually lies within a triangle over the lintel. But this arch effect depends on the wall each side of the opening being wide enough to support the side thrust. Hence in case *A* we allow for weight of wall of height $L \div 2$. In case *B* we allow weight of wall of height L . In case *C* we allow weight of wall of height H (to the top of the wall). In case *C* no arch effect is allowed for as the side abutments being less than half the span are not sufficiently strong to support the side thrust.

Loads

These are of two kinds: Dead load, which includes all walls, floors, roofs, etc., bearing on the lintel or beam. And live load, which includes furniture, stores, people, and all movable loads.

Dead loads can be calculated from the following data:

ROOF LOADS

Description.						Weight in lbs. per sq. ft
Asphalt	..	..	..	..	..	12
Boarding	..	..	..	..	..	$3\frac{1}{2}$ per inch. thickness.

floor is altered. Contraflexure occurs with tension near the top of the beam or floor over the support. Thus, instead of being strengthened, the existing beam may be weakened.

Lintels

To find the required size of a rolled steel joist or timber lintel over an opening in a wall, we must first find the load to be carried. This depends on two factors: the weight of wall, floors, roof, and live load bearing on the beam; and the condition of the supports.

In Fig. 102 three cases are illustrated in which the supporting wall at the sides are:

(*A*) Greater in width than half the width of opening.

(*B*) Less than half the width of opening on one side, greater on the other.

(*C*) Less than half the width of opening on both sides.

<i>Description.</i>	<i>Weight in lbs. per sq. ft.</i>
Roofing felt	$\frac{1}{2}$
Slate battens	1
Slates	7—9
Tiles	12—18 (the higher figure for plain tiles).
Glass	$3\frac{1}{2}$ per $\frac{1}{4}$ in. thickness.
Glazing bars, metal	3
Lead	5 to 7, add for rolls.
Steel purlins	2 to 4.
Timber rafters and purlins	7
G.I. corrugated sheeting (22—18 gauge)	2—3.
Asbestos-cement corrugated sheeting ..	$3-3\frac{1}{2}$ per $\frac{1}{4}$ in. thickness.
Asbestos slates	$3-4$ per $\frac{1}{8}$ in. thickness.
Asbestos flat sheeting	$2\frac{1}{2}$ per $\frac{1}{4}$ in. thickness.
Steel truss (approximately)	From formula, total weight $= .75 \text{ C.s.lb. } 1 + \frac{s}{10}$ <i>C</i> = centres between trusses in feet. <i>s</i> = span of trusses in ft.

WALLS AND PARTITIONS

	<i>Weight in lbs. per sq. ft. of vertical wall.</i>
Brickwork	10 lbs. per 1 in. thickness.
Breeze partitions	8 lbs. do.
Plaster (each face)	9 lbs. do.
Concrete walls	12 lbs. do.
Light timber studded partitions complete	10 to 18 lbs. do.
1 cubic ft. of brickwork in cement mortar (common bricks) = 112 lb. = 1 cwt.	

FLOOR LOADS

Solid reinforced concrete (144 lbs. per cubic ft.).	
Thickness of slab, ins.	$2\frac{1}{2}$ 3 $3\frac{1}{2}$ 4 $4\frac{1}{2}$ 5 $5\frac{1}{2}$ 6
Weight of slab, lbs. per sq. ft. ..	30 36 42 48 54 60 66 72
Timber Floors in Domestic Buildings. <i>lbs. per sq. ft.</i>	
Fir joists, 1 in. boards, and ceilings, up to 11 ft. span ..	20
Do. do. do. over 11 ft. span ..	23
Weight of fir timber, 28 to 45 lbs. per cubic ft.	
Live loads should be allowed for according to the by-laws of the London County Council, as follows:	

LIVE OR SUPERIMPOSED LOADS

<i>Use of Floor.</i>	<i>Superimposed Load in lbs. per sq. ft.</i>
Rooms for domestic purposes, including houses, bungalows, hotel bedrooms	40 to 50

<i>Use of Floor.</i>	<i>Superimposed Load in lbs. per sq. ft.</i>	
Offices: floors above entrance floors	80	
Offices: entrance floors and floors under	80	
Retail shops, garages for private cars	80	
Corridors, stairs, and landings (except in domestic buildings)	100 and upwards.	
Workshops, factories, garages for vehicles other than private cars	150	do.
Warehouses, stationery stores	200	do.

The figures for the last three cases are the minimum. The loads should be calculated.

Tables of safe loads for rolled steel beams are given in maker's hand-books and architect's and engineer's diaries. These tables are for evenly distributed loads. Loads concentrated at one or more points impose greater bending stress in the beam. To allow for this, multiply the actual load by two if it is concentrated in the middle.

For timber lintels a simple rule applicable to ordinary wall loads plus the load from an ordinary domestic floor, is $1\frac{1}{4}$ in. depth for every foot of span, with a minimum of 3 in. Thus an opening of 8 ft. span requires a timber lintel 10 in. deep.

LATERAL EXTENSIONS

In adding to the side, front or back of a building, the extension can be treated as a new building, but care must be taken in bonding the new walls to the existing, making good, carrying out necessary flashings, and cutting openings for doorways.

If it is required to cut away a considerable length of existing wall in order to unite an existing floor with the extension, the method depends on whether the existing building is framed or has load-bearing walls (see Chapter V). The job is more difficult with load-bearing walls, as the wall must be underpinned to place lintels in position, and for any great length intermediate columns will be necessary. With a steel or reinforced concrete framed structure, the panel walls can be knocked out without having to make any provision for supporting the structure above.

In extending factories of framed construction, new stanchions may be necessary. These can be arranged in line and adjacent to the existing stanchions, or side by side with the existing stanchions. In both cases the existing eaves gutter must be removed and a valley gutter formed. With stanchions in line this involves cutting back the roof covering.

VERTICAL EXTENSIONS

In some cases it is necessary to add one or more new floors. If the existing walls are load-bearing it may be possible to build up the walls for one extra storey (the building by-laws should be consulted for wall thicknesses). In most cases an extra thickness of wall, or extra piers, will be necessary from the foundations upwards.

The alternative is to support the new storey on steel stanchions and beams, making an independent structure. If the stanchions can be erected outside the existing walls no interference with the existing building is necessary.

New buildings are often erected over or within existing. Fig. 103

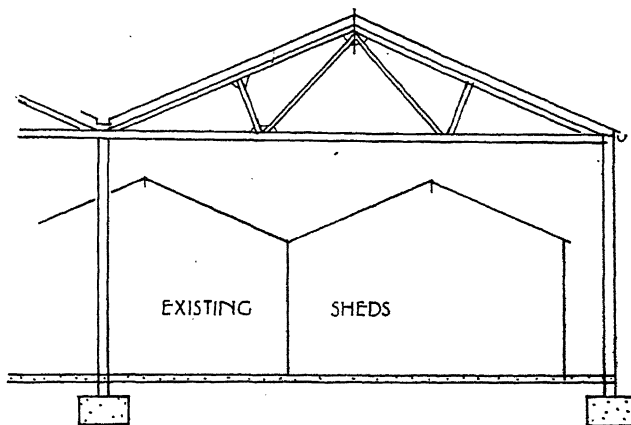


Fig. 103.—NEW FRAMED BUILDING ERECTED OVER AND WITHIN EXISTING

illustrates an example. In this case the new building line was set back, so that the new front stanchions had to be erected within the existing building. This involved preparing new foundations within the existing building (a point to watch here is that if the new foundations are deeper than the existing, the latter must be temporarily supported). The new stanchions were threaded through holes cut in the existing roof. The front wall within the existing building was not erected until the rest were completed. Finally, the existing building was demolished. As the existing building remained in use while the new one was being erected, the operations had to be carefully planned with this in view.

Gallery Floors

These are sometimes required where there is sufficient headroom in an existing building. They are useful in factories where store rooms and offices can be arranged on two floors each of 8 ft. headroom, or little more. In most cases it is advisable to make the gallery floor construction independent of the existing structure. A light steel framed structure is most suitable. Partition blocks or slabs are usually suitable for the walls. The top floor should have a ceiling to keep out dust, and the top of this should be covered with asbestos-cement flat sheeting.

Raising an Existing Roof

This may be required to give extra headroom or where a new storey is added. The new stanchions can be erected either in line and adjacent to the existing, in which case the foundation must be extended, or half-way between the existing. The existing roof must be stripped and the trusses can then be raised with a derrick. Care must be taken, and the trusses must be in good condition.

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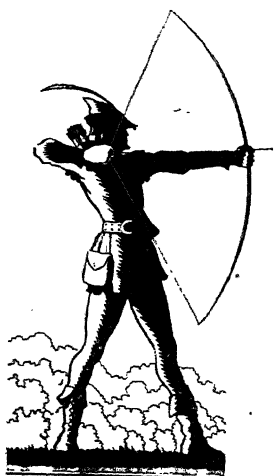
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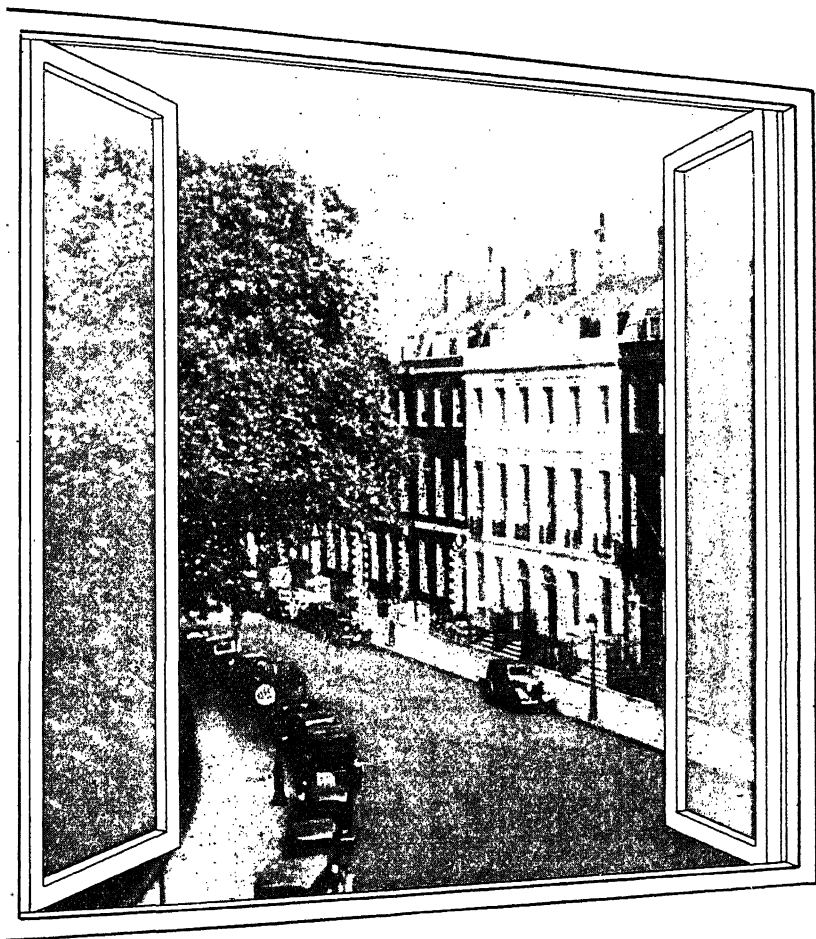
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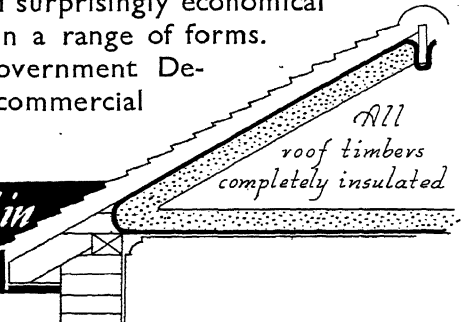
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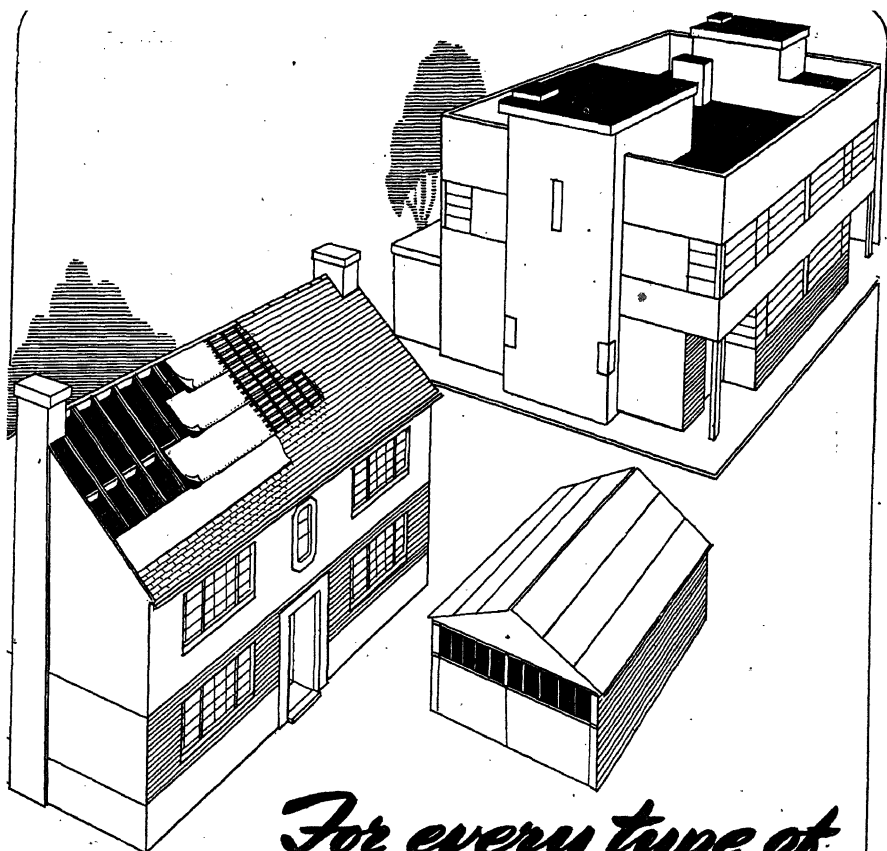
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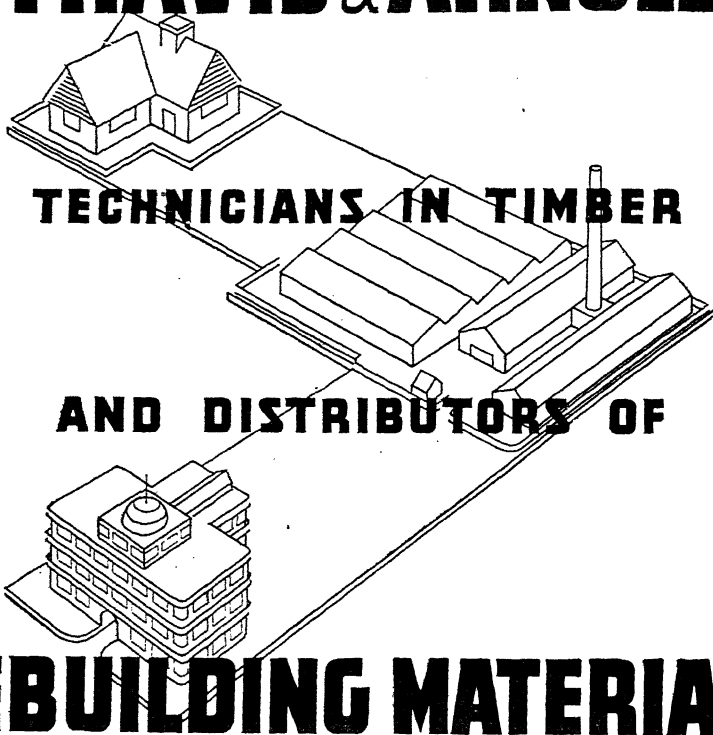
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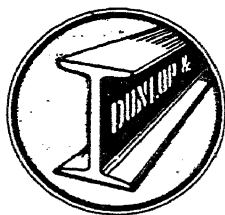
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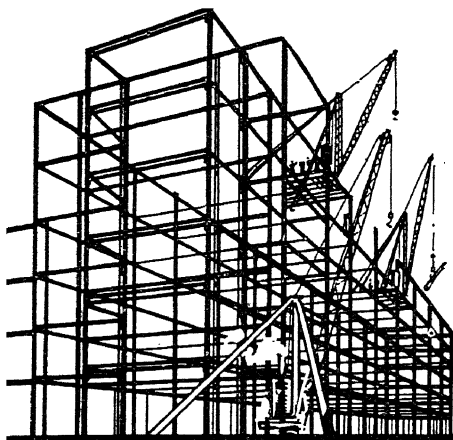
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